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The primary focus of the Environmental Protection Agency's (EPA's) radiation strategy is to implement a program leading to the establishment of necessary radiation controls for the protection of public health and the environment. These controls would include standards, guidelines, and criteria developed through due process including public participation. General topics discussed in this report include the following: Nuclear energy; Naturally occurring radioactivity; Medical and occupation; Nonionizing radiation.

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OFFICE OF RADIATION PROGRAMS

EPA REVIEW OF RADIATION PROTECTION ACTIVITIES - 1974

A PROTOTYPE FOR SUBSEQUENT ANNUAL REPORTS

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ANNUAL REPORT

EPA REVIEW OF RADIATION PROTECTION ACTIVITIES

U.S. ENVIRONMENTAL PROTECTION AGENCY
Washington, D.C.

SEPTEMBER 1975

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FOREWORD

The Environmental Protection Agency was established in 1970 by Executive Order under the Reorganization Plan No. 3 of 1970. One of the authorities transferred under that Plan was that of the Federal Radiation Council which was set up to advise the President on all matters pertaining to radiation and, through this mechanism, to provide guidance to and overview of other Federal agencies on radiation protection matters. While the Council as such no longer exists, the functions now vested in the Administrator of EPA are ongoing functions actively being pursued by the Office of Radiation Programs. This report provides an EPA review of significant radiation protection and industrial activities through December 31, 1975, as well as the underlying issues and problems accompanying them. As an initial effort in this respect, it represents EPA's point of view in terms of priorities, knowledge, and philosophies.

This report was developed over a short period of time with only limited input from and coordination with other Federal and State agencies that have radiation protection responsibilities. Even with this limitation, the report should be of assistance to other agencies and the public, and provide a basis of evaluation for evolving future reports.

EPA plans to involve other Federal agencies early in the process of developing future reports of this type. We believe this report can serve as a basis for structuring an outline of a broader report; we expect to give the other involved agencies an opportunity to comment on an adequate balance in the material presented and to incorporate inputs from many other agencies that have radiation protection related responsibilities and concerns. In this context, it is acknowledged that there are probably many other equally critical issues and problems that are not covered in this first effort that relate to important programs in the Department of the Interior, Nuclear Regulatory Commission, Department of Labor, Department of Defense, Energy Research and Development Administration, Department of Health, Education, and Welfare, and the fifty states. We hope that, during the review of the present report, these agencies will consider the nature of their future contributions. EPA sees this expanded annual report as a basis for presenting the current progress in radiation protection programs.

The Energy Reorganization Act of 1954 (PL 93-438), approved October 11, 1974, abolished the Atomic Energy Commission and established the Nuclear Regulatory Commission (NRC) and the Energy Research and Development Administration (ERDA) effective January 19, 1975. AEC's responsibilities will be continued as part of NRC and ERDA activities. In this report, the names of NRC and ERDA are occasionally used in forwardlooking contexts; elsewhere, we use the name of AEC.

Office of Radiation Programs technical reports are distributed to State and local radiological health offices, Office of Radiation Programs technical and advisory committees, universities, laboratories, schools, the press, and other interested groups and individuals. These reports are also included in the collection of the Library of Congress and the National Technical Information Service. For the reasons stated above, this report has received limited distribution.

I encourage readers of these reports to inform the Office of Radiation Programs of any omissions or errors. Your additional comments or requests for further information are also solicited. Future reports will correct the deficiencies noted in preparation of this issue.

W. D. Rowe, Ph.D.
Deputy Assistant Administrator
for Radiation Programs

CHAPTER 1
EXECUTIVE SUMMARY

The increase in radiation sources in scope and quantity, and the potential increase in radiation dose received by the population from such sources, has resulted in increased efforts in radiation protection activities to reduce unnecessary exposure. At the Federal level significant strides toward control of radiation hazards have been made, including the promulgation of certain standards, criteria, and guides. Improved control technologies in many areas make it feasible to reduce emissions at a reasonable cost to levels below current standards and guides. Many new technologies and applications using radiation are being developed that will require additional standards and controls.

Fifty-three commercial nuclear power plants have been licensed in the United States since 1957, and there have been corresponding increases in mining, processing, and transport of radioactive materials. The medical field has expanded applications of diathermy, lasers, X-rays, and radionuclides for therapeutic and diagnostic purposes. Industrially, X-rays, radionuclides, and lasers have been used increasingly for testing and quality control. With broad availability of relatively inexpensive amateur radio transmitters (citizens band included), the proliferation of microwave transmitters, radio and TV stations, and radar, and the use of powerful satellite communication facilities, there has recently been an increasing superposition of nonionizing radiation energy patterns in the environment. As fossil fuels and geothermal resources are brought up from beneath the earth's surface, radioactive decay products of radon and thoron are added to the background ionizing radiation in the environment. The natural radiation level is also increased by radioactivity in some construction materials, in phosphate fertilizers, and in uranium mill tailings sometimes improperly used for land and road fill. A large source of ionizing radiation is from natural radiation made up of cosmic rays and terrestrial radiation and fallout debris from nuclear device testing. The magnitude of this source varies substantially from one part of the nation to another and exposures from these sources are generally unavoidable.

The primary focus of the Environmental Protection Agency's (EPA's) radiation strategy is to implement a program leading to the establishment of necessary radiation controls for the protection of public health and the environment. These controls would include standards, guidelines, and criteria developed through due process including public participation. Much of this program is carried out by agencies other than EPA who have direct regulatory authority for different sources of radiation exposure. During 1974, EPA, other Federal agencies, States, and other organizations were involved in a variety of major actions affecting the radiation environment. Particularly significant was the discussion of several major problems in the development of nuclear energy in the public forum through the National Environmental Policy Act process in the form of Environmental Impact Statements (EIS's).

The significant events identified during this reporting period were as follows:

- EPA published on May 10, 1974, an advanced notice of rulemaking for a proposed Standard on Environmental Protection for Nuclear Power Operations to assure protection of the public against radiation doses resulting from uranium fuel cycle operations and to limit the long-term impact on current and future populations of long-lived radioactive materials that accumulate as a result of the production of electrical energy via this fuel cycle.

- A draft Environmental Impact Statement (EIS) (WASH-1538) was published by the AEC in September 1974 on the Waste Management Operations at the Hanford Reservation, Richland, Washington.

- An Environmental Impact Statement (WASH-1529) was published by the AEC in September 1974, which discussed its program for the long-term management of commercial high-level and transuranium contaminated waste.

- The AEC published a Draft EIS on Mixed Oxide Fuels (WASH-1327) and a proposed Final EIS on liquid metal fast breeder reactors (WASH-1535) in August 1974 and January 1975, respectively.

- In August 1974 under the independent direction of Professor Norman C. Rasmussen of the Massachusetts Institute of Technology, the AEC published a draft Reactor Safety Study (WASH-1400), which provided an assessment of accident risks from U.S. commercial light water nuclear power plants.

- During 1974, for emergency response planning, the EPA developed proposed protection action guides (PAG's) which provide exposure levels for initiation of protective actions to avoid exposure to radiation from an inadvertent release of gaseous effluents from a nuclear power plant.

- Under the Federal Water Pollution Control Act of 1974, as amended, permits must be issued by the EPA for the discharge of pollutants into navigable waters. In the case of the Colorado Public Interest Research Group versus Russell Train as Administrator of the U.S. Environmental Protection Agency, the United States Court of Appeals Tenth Circuit overturned the lower courts decision and ruled that EPA is responsible, instead of AEC, for issuing water permits for discharge of radioactive waste from nuclear power plants. The EPA's Office of Radiation Programs is not taking any action to develop effluent guidelines pending review of the ruling by the Supreme Court in the fall of 1975.

- The Safe Drinking Water Act of 1974 gave the EPA authority to set standards for radium in drinking water. Interim primary drinking water regulations on proposed maximum contaminant levels for radioactivity are under development. In determining the impact of the proposed standards, the EPA has a program to evaluate cost/effective methods to remove radium from drinking water.

- The AEC issued a regulatory guide for the stabilization of uranium and thorium milling waste retention systems.

- Beginning with the phosphate industry, EPA initiated a program to assess the radiological impact of industries using materials containing naturally occurring radioactivity.

- During 1974, EPA made a study and found that the use of natural gas containing radon-222, under average exposure conditions, does not contribute significantly to an increased background radiation exposure in the U.S. population.

- Radiation monitoring in the vicinity of nuclear facilities increased during 1974. By the end of 1974 there were 19 states participating in a monitoring program under contract with the Atomic Energy Commission. The program essentially covers all operating nuclear power reactors.

- Joint field studies by the EPA/AEC/States were completed, or were in the process of being conducted, at nuclear facilities during 1974 to improve measurement techniques and validate dose computation models, as well as to evaluate control technology for management of nuclear wastes.

- EPA completed an intensive program of evaluating types of high power sources of environmental nonionizing radiation. A unique mobile electronic surveillance van has been designed, procured, and equipped by EPA to make measurements of ambient levels of nonionizing radiation in the environment. Data from these measurement programs will serve as a substantial basis for determining the need for setting an environmental standard in this area.

- The Department of Labor, Occupational Safety and Health Administration, updated its "Nonionizing Radiation Exposure Standard" and issued it on July 1, 1974, in the Federal Register (29 CFR 191097).

- The use of X-rays in the medical and industrial fields is an area of focus for reduction of unnecessary radiation exposure. August 1, 1974, was the effective date for new dental and medical X-ray equipment to meet performance standards developed by the Bureau of Radiological Health, Department of Health, Education and Welfare.*

- The Bureau of Radiological Health, FDA, DHEW, reissued in the Federal Register (39 FR 32094) a revised laser performance standard on September 4, 1974. Their continuing efforts to protect the public from leakage from microwave ovens led to setting August 6, 1974 as the effective date when all microwave ovens must be inoperable if one or both of the independently operating safety interlocks fail to function.

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*Performance standards for cabinet X-ray systems are effective as of April 10, 1975, except for carry-on baggage types which went into effect April 25, 1974.

- The Environmental Protection Agency initiated a careful review of exposures caused by medical procedures in 1974. In order to obtain expert assistance by qualified professionals an Interagency Working Group was formed and all Federal agencies which oversee a health care program which involves radiologic procedures were invited to participated.

- EPA evaluated the exposure commitment of the public (as passenger) due to shipment of radioisotopes on commercial carriers and recommended to Federal agencies charged with the regulation of the transportation of radioactive materials that of dose rate to any passenger should not exceed 0.5 mrem/hour.

- EPA initiated a study by contract, with the University of Texas, School of Public Health, to further determine the dose to the general public due to the release of medical radioisotopes into sewage systems.

- A review and updating of occupational exposure guides was initiated in September of 1974. EPA formed an Interagency Committee on Occupational Exposures to Ionizing Radiation and the advice of this committee will provide the basis for updated exposure guides.

CHAPTER 2
NUCLEAR ENERGY

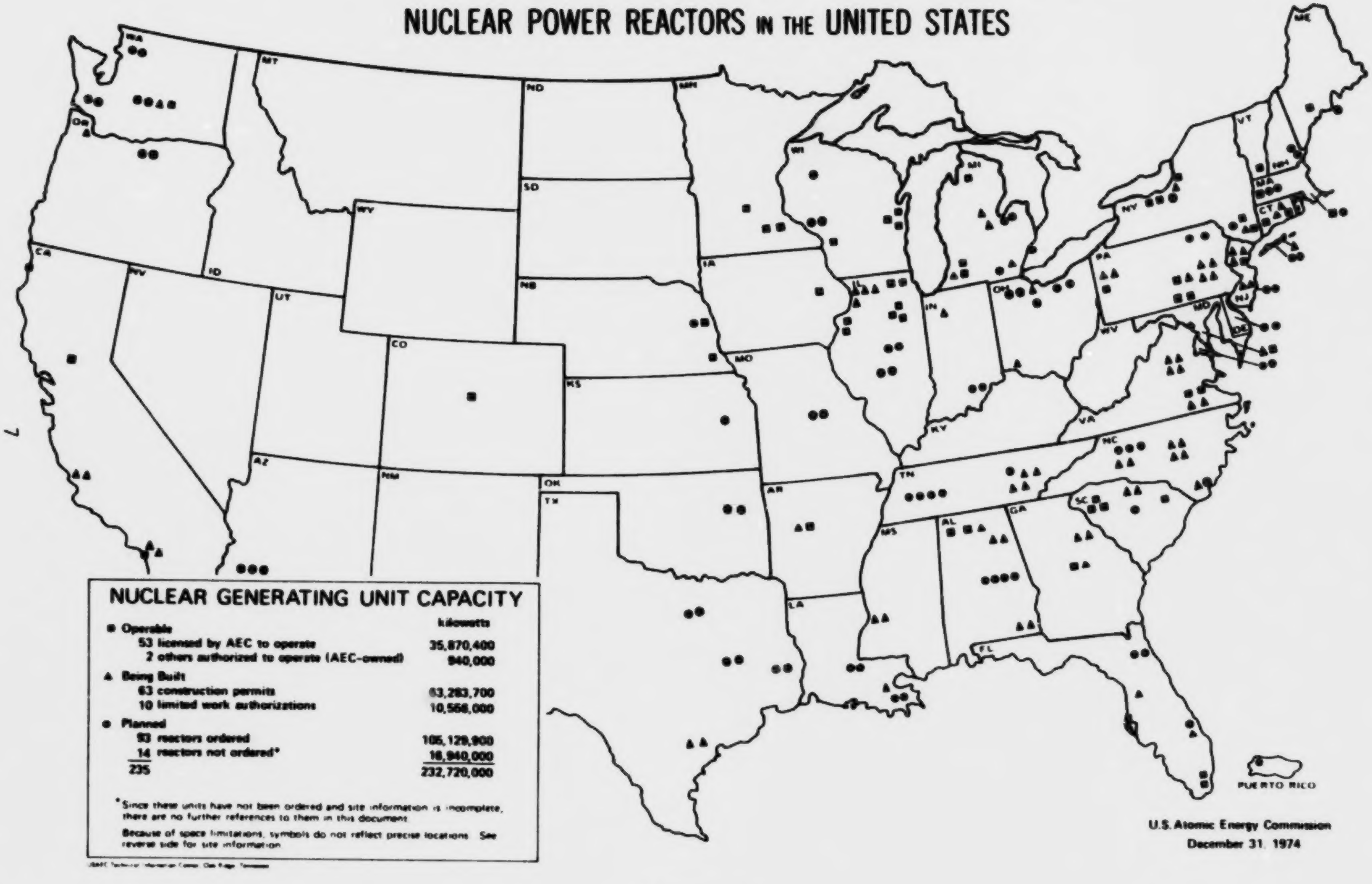
INTRODUCTION

The first major application of nuclear energy was in the use of fission and fusion devices for weaponry. Testing of these devices in the atmosphere has been a major contributor to ambient radiation levels, but since the cessation of above-ground testing by the United States and the USSR under the Nuclear Test Ban Treaty, these levels have been diminishing substantially. The 1974 above-ground tests by the Republic of China and by the French in the South Pacific have made additional contributions to this radioactive burden. Underground testing of devices has continued in the United States and the USSR, as well as an initial atmospheric device detonated by India. The major international issue was pressure for limitation on underground testing of nuclear weapons, as evidenced by the SALT talks. Another major international issue is proliferation of nuclear capabilities as a result of export of "peaceful" nuclear power, e.g., India.

Other commercial nuclear activity in this country and the USSR is primarily centered around ship propulsion. These reactors have been shown to be relatively clean and operated with little environmental contamination. The application of propulsion systems to commercial ships has been less than successful primarily because of economics. In 1974, public reaction to the problems in Japanese ship design raised major concern in that country.

In terms of peaceful uses of nuclear energy, sampling of gases from Plowshare operations such as Rulison and Rio Blanco continued. The future of the Plowshare program is uncertain at this time.

The major commercial efforts in nuclear energy in the United States and throughout the world involve the generation of electricity by large nuclear power plants. Figure 2-1 gives the location of the 53 licensed to operate reactors in the United States as of December 31, 1974. Also included are the nuclear generating capacities, both present [36 gigawatts and projected (16)]. At the present time the nuclear capacity of the 53 commercial power plants accounts for 7 percent of the country's



NUCLEAR POWER REACTORS IN THE UNITED STATES

WA
OR
CA
NV
ID
MT
WY
UT
AZ
CO
NM
ND
SD
NB
KS
OK
TX
MN
IA
MO
AR
LA
WI
IL
MI
IN
OH
KY
TN
MS
AL
GA
FL
SC
NC
VA
WV
PA
NY
MD
DE
NJ
CT
MA
VT
NH
ME
PUERTO RICO

NUCLEAR GENERATING UNIT CAPACITY

	kilowatts
■ Operable	
53 licensed by AEC to operate	35,870,400
2 others authorized to operate (AEC-owned)	940,000
▲ Being Built	
63 construction permits	63,283,700
10 limited work authorizations	10,566,000
● Planned	
93 reactors ordered	105,129,900
14 reactors not ordered*	16,940,000
235	232,720,000

*Since these units have not been ordered and site information is incomplete, there are no further references to them in this document.

Because of space limitations, symbols do not reflect precise locations. See reverse side for site information.

USAEC Technical Information Center, Oak Ridge, Tennessee

U.S. Atomic Energy Commission
December 31, 1974

Figure 2-1

entire electric generation. Projections indicate that by 2000 this percentage may amount to over 50 percent of all electric power in the United States (26). Whether these figures are achieved will depend on the technological development and capacity of alternate power sources to supply a portion of the needed electrical generating capacity.

Utility interest in uranium as a power generation source continues to be stimulated by the compelling advantages of low fuel costs and low fuel shipping costs (because of the energy potential per unit of uranium, which far exceeds that of comparable units of coal and petroleum products), freedom from air pollution control problems, and the ready availability of nuclear fuel in a period marked by declining supplies of other combustibles. Nuclear fission power is clearly freeing considerable amounts of fossil fuel for other uses, and these savings will rise dramatically with its continued growth. It has been estimated that if the current United States nuclear capacity did not exist today, and all generators had to be fired with fossil fuels, over 250 million barrels of oil per year would be required in addition to current requirements.

Three generic issues evolved in the nuclear energy controversy during 1974: (a) Should we have nuclear power at all? (b) How safe should it be made?, and (c) What form of nuclear power should be allowed? Nuclear power plants are currently in operation for generation of electricity both in this country and abroad and there have been tremendous investments in capital and labor. Since there is a current need for energy independence, the first question cannot be debated at this time (1). However, the rate of future expansion is certainly a question that can and must be addressed since the decision on whether to pursue nuclear energy commercially predates NEPA and therefore expansion has never been addressed in the public forum. With respect to future nuclear energy, the question of how safe (in terms of planned and accidental releases) nuclear power can be made and how much should be spent to achieve such goals, is paramount. Finally, the form of nuclear power involves technology and economic questions of light-water reactors with uranium fuel, plutonium enriched fuels, high temperature gas reactors and breeders, as well as fusion. These are all part of the analysis which must be taken into account and weighed against other methods of producing energy.

The specific issues which are facing nuclear power at this time represent several unsolved problems. The first is long-term waste disposal. There is urgent need to develop an ultimate disposal method for both commercial and government high-level and low-level nuclear wastes. The generation of large amounts of high-level radioactive material and fission products require that they be disposed of by some method to assure long-term containment. Second, the possibility of very large, but highly improbable, accidents at nuclear power plants is a primary issue, and considerable effort has been addressed to it in terms of (a) quantification of risk from nuclear power plants through the Rasmussen Study, (b) insight into developing methods for accepting levels of risk for society, and finally, (c) the need for development of emergency response plans should such accidents occur. Third, as new technologies are developed which use separable fission materials such as plutonium, the problems of safeguards once again need to be addressed in the public forum and resolved. Fourth, although planned releases from nuclear power plants are indeed low, the buildup of long-lived nuclides in the environment has become of increasing concern. Fortunately, this buildup can generally be controlled once the problems have been identified. Effluent and general environmental standards are effective means of addressing this type of problem.

In 1974, there were significant radiation protection activities which are likely to affect the public and the environment in relation to radiations, their sources, and measures for their control. For this year, the primary focus has been on nuclear power and its control, and, to a more limited extent, on other parts of the nuclear fuel cycle, i.e., the stages of radioactive material handling from the mining to the ultimate disposal of such material. These activities are described in this chapter.

MAJOR RADIATION PROTECTION ACTIVITIES

During 1974 there were numerous nuclear related activities, most of which followed from past events. New concerns have also developed concomitantly with the nuclear industry growth and increased public awareness. Such activities involve to varying degrees Federal and State agencies, public interest groups, and knowledgeable individuals. The following discussions provide an insight into the major events, critical issues, and imminent plans for dealing with these various problems.

STANDARD SETTING ACTIVITIES

NUCLEAR FUEL CYCLE

The sequence of radioactive material passing through several nuclear facilities during production and utilization of nuclear fuel for a light water reactor, which is the predominant reactor type in use today, typifies the nuclear fuel cycle. The sequence includes the mining and milling of uranium, conversion of ore concentrate to uranium hexafluoride (UF_6), enrichment in the isotope uranium-235 (U-235), conversion of enriched to fuel material, UO_2, fabrication of fuel elements, nuclear power generation, reprocessing of spent fuels, and ultimate disposal of radioactive waste. (36)

In recognition of the problems of population exposure from the uranium fuel cycle, EPA published in the Federal Register on May 10, 1974 (37), an advance notice of rulemaking designed to provide environmental and public health protection (37). Then in December 1974, EPA issued a draft environmental statement for proposed rulemaking action (for interagency review only) on the uranium fuel cycle standards. These standards would limit radiation doses to the general public and would also limit quantities of long-lived radioactive materials in the general environment attributable to planned releases from operations contributing to the generation of electric power through the uranium fuel cycle. (33) These proposed standards will limit radiation exposure from planned releases outside the boundaries of nuclear power light water reactors and outside of all facilities, including transportation, that are involved in the processing, fissioning, and reprocessing of uranium for these reactors. The standards will cover the process from the time uranium ore leaves the mines through the reprocessing of uranium after burnup in reactors and its eventual recycling back into the fuel supply. This will (a) assure protection of the public against radiation doses resulting from fuel cycle operations, and (b) limit the long-term impact on current and future population of long-lived radioactive materials that accumulate as a result of the production of electrical energy. The guideline for this standard is the "as low as practicable" concept. Effective consideration of "as low as practicable" involves judgments of trade-off between public health considerations, cost of effluent control, and overall benefit. The proposed standards for individual doses and for limits on total quantities of long-lived radionuclides are presented in Table 2-1.

Standards in categories of Section A of Table 2-1 are designed to address doses due to short-lived fission produced materials and naturally occurring materials, while those in Section B specifically address

Table 2-1 The Proposed Standards for Normal Operations of the Uranium Fuel Cycle

A. Individual Dose Limits

1. Whole body	25 millirems/year
2. Thyroid	75 millirems/year
3. Other organs*	25 millirems/year

B. Limits for Long-Lived Radionuclides

1. Krypton-85	50,000 curies/gigawatt-year
2. Iodine-129	5 millicuries/gigawatt-year
3. Transuranics**	0.5 millicuries/gigawatt-year

C. Variances

At the discretion of the regulatory agency (licensor) for temporary and unusual operating circumstances to insure orderly delivery of electrical power.

D. Effective Dates

1. Two years, except
2. 1983 for krypton-85 and iodine-129

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*any human organ except the dermis, epidermis, or cornea

**limited to alpha-emitters with half-lives greater than one year long-lived radioactive materials. The standards for environmental burdens of specific long-lived radionuclides are expressed in terms of the quantity of electricity produced, in order to assure the public that the risk associated with any long-term environmental burden is incurred only in return for a beneficial product: electrical power. The standard permits these radionuclides to be released up to the specified level at any time or location and at any rate that will not exceed the individual dose limitations. The standards proposed apply to all operations except mining within the fuel cycle, including milling, conversion, enrichment, fuel fabrication, operation of light-water-cooled reactors, fuel reprocessing, and transportation of radioactive materials in connection with any of these operations. A variance is proposed to permit temporary operation in the presence of unusual operating conditions to assure the orderly delivery of power.*

PLUTONIUM

EPA has been evaluating the environmental impact of contamination by transuranium elements, and considering whether new guidelines or standards are needed to protect the public. These nuclides include long-lived, toxic materials which could constitute an irreversible commitment to the environment and a health hazard to the population. Produced in nuclear reactors, these isotopes include plutonium, which is valuable as weapons material, as fuel, and as a power source for space and medical applications. Small releases of these isotopes have taken place, and on the basis of projection of present experience more are anticipated in the future as ways of using these materials are increased. (12) Among the problems of plutonium which are being considered are those dealing with its environmental transport and pathways to man, especially the possible health effects resulting from inhalation of particulate matter (28).

On February 14, 1974, the National Resources Defense Council (NRDC) petitioned the Atomic Energy Commission (AEC) and the Environmental Protection Agency (EPA) requesting a reduction in the existing radiation protection standards applicable to the internal exposure of man from hot particles (particulates--plutonium and alpha-emitting actinides). Although the retention of these particulates in the lung tissues may not cause whole organ damage, it may cause rather intense damage localized at the spot of retention. A report on "Radiation Standards for

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*EPA published in the Federal Register on May 29, 1975 a notice of proposed rulemaking for the Uranium Fuel Cycle for review and comment.

Hot Particles" by A. R. Tamplin and T. B. Cochran was used as justification for this petition. (15) The views expressed in the petition will be considered in the rulemaking process along with other expressed comments.

Since the release of long-lived radionuclides represents an irreversible, long-term environmental commitment, realistic control is only practicable at the point of release. In dealing with this situation the EPA has prepared a report evaluating the cumulative impact of releases of plutonium and other long-lived radionuclides (38). They published a "Notice of Intent to Review the Need for Establishing New Rules for Plutonium and Transuranium Elements," and then held public hearings in Washington, D. C., on December 10-11, 1974, and in Denver, Colorado, on January 10, 1975, to permit public input to the standards development program and to solicit technical information and viewpoints. A technical "Statement of the Problem" and several analysis papers have been prepared to define the scope of the problem.

The comprehensive work program that has been initiated includes analysis of related research, engineering and operating programs, and studies on actinides. The program plans include development of (a) damage function-health effects model, (b) regulation based on "controlled containment" philosophy, and (c) guidelines for cleanup and restoration of contaminated areas. Future activities include development of general guidelines for plutonium in the environment and, if needed, actinide standards for plutonium recycle activities and for plutonium fuel cycle liquid metal fast breeder reactors (LMFBR's). Close liaison on this activity has been established with a number of other governmental agencies, especially ERDA and NRC through the establishment of an interagency task force.

"AS LOW AS PRACTICABLE"

On June 7, 1971, the Atomic Energy Commission announced proposed numerical guidelines for design and limiting conditions for operation of light-water-cooled nuclear power reactors (LWR) to keep radioactive material in effluents released to unrestricted areas "as low as practicable." (24) A final environmental statement (WASH-1258) concerning this matter was then required and published during July 1973. For the final guidelines, the AEC has announced that if the design objective and operating limits established in Appendix I should prove to be incompatible with any generally applicable environmental protection standard established by EPA, the objectives and limits will be modified as necessary.

The "as low as practicable" concept as used in Appendix I, 10 CFR Part 50 (24) means that radioactive material in effluents released from LWR facilities to unrestricted areas must be kept as low as practicably achievable taking into account the state of technology and the economics of improvement in relation to benefits to the public health and safety and to the utilization of atomic energy in the public interest. (22)

The design objective guides expressed as quantities and concentrations of radioactive material in effluents (liquid or gaseous) are sufficiently conservative to provide reasonable assurance that, for most locations having environmental characteristics likely to be considered acceptable by the AEC for a nuclear power reactor site, resultant increases in radiation dose to individual members of the public living at the site boundary will generally be less than 5 millirem per year. (22) Higher quantities and concentrations than those suggested in the design guides may be deemed to meet the requirement for keeping levels of radioactivity in effluents as low as practicable if the applicant provides reasonable assurance that the proposed higher quantities and/or concentrations will not result in annual doses to any organ of an individual in excess of 5 millirem from liquid or gaseous effluents.*

ENVIRONMENTAL IMPACT STATEMENTS

The National Environmental Policy Act (NEPA) of 1969, implemented by Executive Order 11514 and the Council of Environmental Quality's (CEQ's) Guidelines of August 1, 1973 (38 FR 20550), requires that all agencies of the Federal Government prepare detailed environmental impact statements on proposals for legislation and other major Federal actions significantly affecting the quality of the human environment. NEPA requires that agencies include in the decision-making process appropriate and careful consideration of all environmental effects of proposed actions, explain potential environmental effects of proposed actions and their alternatives for public understanding, avoid or minimize adverse effects of proposed actions, and restore or enhance environmental quality as much as possible. The EPA in reviewing environmental impact statements follows the directive of the NEPA and the requirements of section 309 of the Clean Air Act of 1970.

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*On May 5, 1975, the NRC published a notice in the Federal Register (Appendix 1, 10 CFR 50) of the design objective guides for discharges of radioactive materials to the environment from individual reactors to be effective July 1, 1975. These new guides are: Liquid Effluent-3 mrem whole body; 10 mrem any organ; Gaseous Effluent-5 mrem whole body; 15 mrem per reactor annual dose limit to skin; Radioactive Iodine and Particulates-15 mrem per year dose to any organ, including thyroid, from all pathways.

Four major environmental impact statements (EIS) were issued by the AEC during 1974. The issues were (a) waste disposal (WASH-1539) (19), (b) the use of recycled plutonium mixed oxide fuels (GESMO) in light-water-cooled reactors (WASH-1327) (21), (c) the development of the liquid metal fast breeder reactor (LMFBR) (WASH-1535) (25), and (d) waste management operations at the Hanford Reservation, Richland, Washington, (WASH-1538) (20). Additional EIS's submitted to EPA for review and comment included light water reactors, a fuel reprocessing plant, uranium mills, and other related facilities.

MANAGEMENT OF COMMERCIAL HIGH-LEVEL AND TRANSURANIUM-CONTAMINATED RADIOACTIVE WASTE (WASH-1539)

The AEC draft environmental impact statement (EIS) WASH-1539 was published (19) during September 1974. The basic purpose of the draft statement was to assess the environmental consequences of developing an engineered surface storage facility for retrievable commercial high-level wastes (RSSF)* of evaluating geologic formations and sites for the purpose of developing a geologic pilot plant for the permanent disposal of these wastes; and of providing retrievable storage for commercial transuranium-contaminated waste pending availability of permanent disposal. This EIS included statements on such points as environmental impact and unavoidable adverse environmental effects, alternatives in sites and disposal techniques, resource commitments, and a cost-benefit analysis. The desirability of Federal ownership and control of commercially generated high-level transuranium-contaminated waste was discussed. It was concluded that the best solution for the development and operation of a permanent disposal system was to require Federal control, even though no specific permanent system was identified.

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*Plans for development of an interim retrievable surface storage facility (RSSF) have since been terminated by the Energy Research and Development Administration (ERDA). Efforts are now being redirected toward long term waste disposal methodology.

Interim above ground storage was identified by EPA as a secondary concern, compared to the ultimate waste disposal question. The AEC Retrievable Surface Storage Facility (RSSF) proposed in WASH 1539 (19) was not the only form of interim storage or "insurance" that should have been evaluated. Other options, such as long term storage of spent fuel at the reactors or in other facilities with no reprocessing, should have been considered, as well as extended storage of the solidified high level waste at the reprocessing facility where it was generated. EPA believed it necessary to consider all such alternatives because the scope of the waste management problem may be significantly amplified in the future if the proposal to use recycled plutonium fuel in LWR's and if the program for developing the fast breeder reactor fuel cycle are pursued.

AEC's primary emphasis in the EIS was placed on the development of a retrievable surface storage facility (RSSF). EPA concluded that an environmentally suitable facility could probably be designed and sited. Several EIS reviewers made the point, however, that the draft statement did not contain sufficient information to support any specific site or storage technique.

Most reviewers felt that the primary concern of any waste management program should be the development of an acceptable ultimate disposal technique. In general, it was felt that unless it can be demonstrated that at least one acceptable method for ultimate disposal, either retrievable or inretrievable, can be developed in the reasonable near future, nuclear energy programs will be in serious jeopardy as a viable energy option. Further, because of the existing AEC weapon production waste, the U.S. already has been committed to a sizeable ultimate disposal program, and there is no going back. The primary concern here is not which specific ultimate disposal method should be followed, but rather, assurance that at least one method does exist that is satisfactory from an environmental standpoint. Once this is accomplished, tradeoffs between methods and timing of implementation can be made.

While it is recognized that the generation of power by nuclear means offers certain benefits from the environmental viewpoint, the question of how to manage properly the hazardous waste produced during such power generation remains one of the major unresolved problems. EPA is especially concerned with the long-term nature of the potential environmental hazards presented by these wastes. Complicating this problem is the fact that physical and administrative controls for this waste will have to be exercised over the millenia of the future. With the recent policy redirection, (placing priority on the ultimate waste disposal problem instead of the RSSF and other forms of interim disposal) it appears that a comprehensive review of the total waste management program will be forthcoming in the near future. EPA believes there is reasonable cause for hope that an acceptable solution will emerge.

GENERIC ENVIRONMENTAL STATEMENT MIXED OXIDE FUELS (GESMO) WASH-1327

In August 1974, the AEC published a four volume draft Generic Environmental Statement on Mixed Oxides (GESMO) Fuels for use in light water reactors (LWR) (21). The principal issues addressed by the AEC staff were (a) the acceptability of the environmental impacts of plutonium recycling in light water reactors based on cost-benefit-risk analysis, (b) the safety of using mixed oxide fuels in a LWR, and (c) the achievement of adequate levels of protection for facilities and special nuclear materials.

The use of recycled plutonium in reactors will require licensing by the Nuclear Regulatory Commission (NRC), even in LWRs already licensed for full power operation with uranium fuel. Comments from the reviews of NRC environmental impact statements for the fabrication and the use of mixed plutonium and uranium oxide fuels in LWRs will provide information necessary to make a decision on the possible need to amend the proposed EPA Uranium Fuel Cycle Standard to control environmental releases from plutonium recycle facilities.

EPA stated that the GESMO EIS lacked sufficient information concerning the behavior of plutonium in the environment to allow an independent dependable decision to be made on the acceptability of the potential environmental impact.

Moreover, EPA's preliminary findings (4) were that the implementation of plutonium recycle on an industry-wide basis appeared to be marginally acceptable from a cost-benefit balance. The analysis indicated that the timeliness of the program implementation did not appear to be critical. With the application of revised cost-benefit analysis the timeliness might be even less critical, and the cost/benefit balance even more marginal. It also appeared that the program could result in some environmental advantages. Within this perspective, the principal conclusions reached on the plutonium recycle program were that (a) before a full scale mixed oxide program is implemented, a commitment should be made to an acceptable safeguards program, including the completion of the necessary selection of a procedure, its development, and the securing of regulatory or legislative approvals for its implementation, including funding mechanisms; and (b) before actual full-scale mixed oxide fabrication and fueling of light water reactors is commenced, the safeguards program should be implemented, the ultimate waste disposal concerns about transuranic wastes should be resolved, and an accident analysis of specific plutonium recycle reactor designs should be completed for each proposed application.

LIQUID METAL FAST BREEDER REACTOR (LMFBR) WASH-1535

The Atomic Energy Commission prepared a draft environmental impact statement (March 14, 1974) (25) designated as WASH-1535, stating that commercial utilization of the liquid metal fast breeder reactor (LMFBR) is a promising method for meeting a substantial portion of the Nation's future energy needs, and the projected total impact on the environment is low and therefore acceptable. For economic reasons, the development of the LMFBR should proceed expeditiously in order to achieve early commercial introduction. The Environmental Protection Agency was not able to verify independently the timeliness of the recommendation for early commercial development or to assess fully the cost-environmental risk issues of the LMFBR program or other alternatives. The following are summaries of the areas in which EPA recommended additional studies to verify acceptability of the concept (18).

- AEC planning for the safeguards program rested on the assumption that whatever measures are deemed necessary can and will be provided within the constraints of program economics. Information in the draft statement did not clarify sufficiently the constraints that may be imposed by limitations on the cost or resources.

- The final statement should indicate the degree of confidence that can be attached to the projected risks regarding health effects associated with plutonium, so that this factor can be considered in evaluating the potential impact on public health. Most current evaluations of potential health effects from inhaled plutonium particulates are based on a uniform distribution of radiation dose to the lung. However, a concern about the adequacy of such an approach has been expressed by the International Commission on Radiation Protection, EPA, and by others.

- The final statement should indicate what counter measures are being considered by the Commission, in case further health effects research indicates that non-uniform distribution of radiation dose from transuranium elements leads to significantly greater estimates of health effects for humans than those presented in the draft statement.

- Because the draft statement was not sufficiently quantitative in the area of reactor safety, EPA was unable to form an opinion on the adequacy of the approaches to be taken in many important areas.

- The final statement should provide a meaningful comparison of LMFBR risks relative to those from light water reactors, or else it should indicate plans to quantify accident risks.

In comments on the cost/benefit analysis methodology of the proposed Final Impact Statement, EPA questioned the use of a low discount rate and certain empirical assumptions such as capital cost estimates. Sufficient uncertainties exist in the projected demand for electrical energy to make premature a full commitment to commercialization of the LMFBR with a highly fixed time schedule. If additional time were available, it would provide ERDA with an opportunity to re-evaluate the development program to provide a better environmental protection. The AEC's assumption with respect to energy demand and other significant factors, as well as its conclusion regarding the timing of LMFBR commercialization, should be critically reviewed throughout the development program. These reviews may indicate that the date of commercialization necessary from an economic perspective may not be as presently calculated nor as critical as ERDA assumed.

Under current procedures of the National Environmental Policy Act, the present review process may constitute the only comprehensive analysis that will be made on the LMFBR as a national program. Future reviews may well be on a plant-by-plant basis, as is now done with light water reactor plants and associated facilities. The current LMFBR program could potentially have far-reaching economic and social implications, including large-scale commitment of national resources and possible adverse environmental impacts. Therefore, it is essential that the environmental statement provide sufficient information to enable informed conclusions to be reached regarding the desirability of this national program in relation to alternative programs for accomplishing the same objective.

A public meeting was held August 13, 1974, between the Atomic Energy Commission and the Environmental Protection Agency on the Liquid Metal Fast Breeder Reactor Environmental Impact Statement (41). This meeting was called by mutual agreement between EPA and AEC in order to keep the public fully informed of the discussions that have taken place between the staffs of these two agencies on problems associated with the LMFBR. These discussions have provided the public with an opportunity to comment meaningfully on this project. The subject areas which were discussed were plutonium toxicity, transportation of radioactive materials, radioactive waste disposal, reactor plant safety, and cost benefit analysis.

The Atomic Energy Commission has since prepared a proposed final environmental impact statement document which addresses the questions raised above on the draft environmental impact statement, and this has been submitted for federal agency review.

WASTE MANAGEMENT OPERATIONS AT THE HANFORD RESERVATION (WASH-1538)

The purpose of this environmental statement, released during September 1974, was to reassess the environmental impact of the Hanford Reservation Waste Management Operations in order to assure that further major changes in the operational programs would have minimum adverse environmental consequences (20). In addition, an attempt was made to account for those environmental consequences that may not have been fully evaluated at the outset or at each stage of the waste management program. This statement is the evaluation of a long-existing program and consequently the results are presented as of a particular date, December 31, 1972. Preliminary data for 1973 were included where available.

In summary, the report anticipates that the quantities of radioactive materials released to the environment from future Hanford operations will be less than the 1972 quantities. This is a result of modifications and construction of new facilities for effluent control and curtailment of production activities. The primary anticipated benefit of the Hanford Waste Management Operations Program is the continued isolation of significant quantities of radioactive and other waste materials from man's environment. At the end of the year (1974) this environmental impact statement was under review by the federal agencies concerned. (31)

ENEWETAK EIS (16)

Enewetak Atoll in the Marshall Islands served as the primary site of U.S. nuclear weapons testing in the Pacific from 1948 through 1958. In 1972, the U.S. announced it was prepared to release Enewetak to the Trust Territory Government with the expectation that a radiological cleanup and rehabilitation program would be necessary to render the atoll suitable for human rehabilitation. The Enewetak people currently reside on Ujelang Atoll which is more than three times smaller in land area than Enewetak. During late 1972 and for most of 1973, the AEC sponsored an extensive radiological survey to assess the conditon of Enewetak. The results, published in March 1974, form the basis for specific recommendations for cleanup and rehabitation, which are to be conducted by the Department of Defense and the Department of the Interior, respectively. An important step in the AEC's deliberations on its recommendations was a series of presentations in September involving the Enewetak people. These presentations were made in conjunction with the issuance by the Defense Nuclear Agency of the draft environmental impact statement for the Cleanup, Rehabilitation and Resettlement of the Enewetak Atoll—Marshall Islands. EPA's primary comment was directed to assuring that waste disposal methods for plutonium would be adequate to assure isolation of the material from the biosphere.

FUEL REPROCESSING

Experience to date with spent fuel reprocessing plants shows that there are environmental problems associated with the discharge of radioactive materials that need to be resolved by proper plant design and operation. There has not been a private irradiated fuel reprocessing capacity since early 1972, when Nuclear Fuel Service, Incorporated closed down its West Valley, New York facility for major changes. Commercial operation is not scheduled to be restarted there until 1978. Allied-General Nuclear Service's Barnwell (South Carolina) Nuclear Fuel Plant plans to be the first, with commercial operation due late in 1978. As a result of detailed study of design and preoperational testing, General Electric Company announced on July 8, 1974 that the start of operation of the Midwest Fuel Recovery Plant at Morris, Illinois, is indefinite. The plant has been expected to be placed in operation during 1974. In these circumstances, several industry actions were taken to increase storage capacity for spent fuel removed from power reactors and destined for reprocessing (16). The need for reprocessing spent fuel is being questioned from an economic standpoint.

RADIOACTIVE WASTE MANAGEMENT FIELD STUDY EFFORTS

During 1974 several ORP funded field study efforts were continued or initiated which address the problems attendant to the disposal of "low-level" radioactive wastes in State-licensed burial grounds. One of the primary influences which led ORP to devote professional and financial resources to this area was the Radioactive Waste Management Task Force of the National Conference of Radiation Control Program Directors. It is through this Task Force that representatives of the States, which either presently have such a waste disposal facility or may have one in the future, can identify individual and mutual problems and seek help from the federal government. Several past ORP in-house, contract and field efforts have had their "birth" in just this way.

Due to the natural processes involved in considering the potential environmental impact of these burial activities, most of the field studies take over a year to complete their experimental phase. One such study (to investigate the waste retention capability and hydrogeological characteristics of the state-licensed burial ground in New York) has completed its data collection and preliminary analysis, interpretation, and report preparation efforts. A final published report should be available before the end of 1975.

A similar field study to investigate the state-licensed site in Kentucky was initiated in 1974. To augment the technical capabilities of the state, ORP, through an interagency agreement, has obtained the services of the U.S. Geological Survey to provide expert assistance in characterizing the hydrologic and geologic characteristics of the site and its surroundings. A unique feature of the operations at this site is the use of an evaporator to routinely treat leachate, generated by the interaction of groundwater and the wastes. A special portion of the overall study in Kentucky is being focussed on this aspect of the burial site operation. It is being conducted by ORP's Radiochemistry and Nuclear Engineering Facility located in Cincinnati, Ohio. A report on this effort should be available by the end of 1975.

Additional field study efforts are being finalized with state agencies in New York to provide more detailed evaluations of conditions at that site. These efforts are expected to start in the fall of 1975 and result in technical reports in about 18 months. The studies are designed to continue collection of data for several years. Updated reports and evaluations will be prepared and published periodically during that period.

NUCLEAR FACILITY ACCIDENT PROBLEMS

RASMUSSEN STUDY (WASH-1400)

The Rasmussen Study (29) was a reactor safety study performed under the independent direction of Professor Norman C. Rasmussen of MIT and sponsored by the AEC. A draft was published in August 1974. The purpose was to estimate the public risks that could result from potential accidents in commercial nuclear power plants of the type now in use (such as pressurized water and boiling water reactors). The risks had to be estimated, rather than measured, because to date there have been no nuclear commercial power reactor accidents which have led to major release of radioactivity or injury to any member of the public. The methods used to develop these estimates are based on those developed by the Department of Defense and the National Aeronautics and Space Administration in the last ten years. The estimated risks were then compared to risks to which the public is already exposed from other causes.

Study Findings. The basic conclusion of this study is that the risks to the public from potential accidents in nuclear power plants are very small. This is based on several study conclusions: (a) the consequences of potential reactor accidents are no larger, and in many cases, are much smaller than those of non-nuclear accidents; (b) the likelihood of reactor accidents is much smaller than many non-nuclear accidents having similar consequences; (c) the greatest risk is the release of radioactive fission products, such as iodine, xenon, and strontium from the reactor core. A large quantity of such fission products might be released through an accident which causes the reactor core to melt. The report indicates that it would take such an accident, combined with other unfavorable and unlikely circumstances, to produce measurable health effects. It was calculated that for each year of reactor operation, there is 1 chance in about 170,000 that such a combination of events would occur.

According to the study, while a reactor accident might cause immediate death or injury to persons in the reactor's proximity, the chances of consequences to personal health of large numbers of people are extremely small. Also a serious nuclear accident would cause no physical damage to property beyond the plant site other than contamination with radioactive material. However, the principal concern should be that of environmental monitoring in the accident vicinity to insure that the amount of radioactivity ingested remains small. Such monitoring should be continued for one to two months following an accident until radioactive iodine, the nuclide of greatest concern, has decayed to an insignificant level. The study indicates that little monitoring would be required after this time period, and that the production of thyroid nodules is the only anticipated long term health effect which would occur at rates significantly higher than normal.

Response to the Study. There has been a large response to the Rasmussen Study, both by government agencies and private groups. Some of the major EPA comments on the draft Rasmussen Report are summarized here in the following paragraphs.

The study is innovative in both its concept and methodology, and provides a forward step in risk assessment of nuclear power generators. The general methodologies and rationale developed in the study to determine risk levels appear to provide a meaningful basis for obtaining useful assessments of accident risks of nuclear power plants, but it is possible that several sources of potential accidents were underestimated or overlooked.

Appendix VI (environmental consequences) was found by EPA to be incomplete in a number of respects. For example, if the recommendations of the Biological Effects of Ionizing Radiation (BEIR) Report (8) are followed, in certain cases the consequences estimated in the study may be low by factors of 2 and 5. In addition, the evacuation model assumed for the consequences calculation in the reference case also appears somewhat overly optimistic. Based on the information presented in the study, this could increase consequences by at most a factor of 2 to 4 (i.e., no evacuation). The combination of these factors, therefore, indicate that the draft WASH-1400 may have significantly underestimated the consequences associated with the "high" release accident sequences.

Although the study indicates that no absolute judgment on nuclear power plant acceptability was intended, the comparative risk approach highlighted in the summary may well imply an acceptability judgment to the average reader. The Rasmussen Study has estimated probabilities of various kinds of nuclear risks. However, the problem remains to determine the levels of such risk acceptable to society which was not included, nor should it have been, in the original study. Thus, the quantification of risk determined by the study and implications of their acceptability should be clearly differentiated to eliminate any potential confusion.

The second phase of EPA's review includes an in depth review of selected aspects of the study with technical assistance being provided through a contract. This second phase is expected to be concluded in the fall of 1975 when a report is to be released detailing all of EPA comments.

EMERGENCY RESPONSE PLANNING ACTIVITIES

Federal Interagency Agreement. The responsibilities of certain Federal agencies in connection with nuclear incident planning for fixed facilities, including provision of planning assistance to state and local government, were initially defined in an Interagency Agreement signed in 1973. The Office of Emergency Preparedness, Atomic Energy Commission, Environmental Protection Agency, Department of Health, Education and Welfare, and Defense Civil Preparedness Agency are signatories to the agreement (2). Since then, a revised draft (43) of the interagency agreement is being circulated for comment. This has been dictated by the dissolution of AEC and formation of the Nuclear Regulatory Commission (NRC) and the Energy Research and Development Administration (ERDA); and also by the need to clarify responsibilities among Federal agencies in connection with nuclear incident emergency planning at the Federal level for fixed nuclear facilities and transportation incidents; and for providing assistance to State and local governments for emergency planning related to such incidents.

Protective Action Guides. A protective action is an action or measure taken to avoid the exposure to radiation from inadvertent release of radioactive materials. The term Protective Action Guide (PAG) is defined as the projected absorbed dose to individuals in the general population that warrants protective action following a contaminating event (31, 35). The projected dose is the dose that would be received by individuals in the population group from the contaminating event if no protective action were taken. If the projected dose exceeds the PAG, protective action is indicated. The nature of the protective action, under any specific circumstance, may vary depending on the nature of competing risks. The preferred protective action may not be called for in all circumstances. In some cases, a variety of protective actions may be indicated.

In the event of a nuclear accident with subsequent releases of radioactive material, there will be a hazard from airborne material and from contamination of foodstuffs and property. The three most critical pathways of exposure then would be (a) direct exposure from cloud or plume passage, (b) exposure from foodstuffs, and (c) exposure from contaminated property or equipment. These pathways and others are being investigated to determine appropriate PAGs. (31, 35, 32)

The protective measures considered appropriate for achieving the objectives of the Protective Action Guides include evacuation, sheltering, prophylaxis, respiratory protection, and controlled access. Evacuation is effective for protection against any radiation exposure. Sheltering is considered, but it is probably ineffective against continuous gaseous releases after about two hours in the absence of shelters with ventilation control. Prophylaxis may be necessary to provide blocking of the thyroid; however, because of some potential side effects, this may not be advisable. If appropriate, apparatus can be provided for respiratory protection which can be effective. Finally, controlled access to affected areas is effective in preventing additional members of the public from being significantly exposed.

EPA has developed recommended Protective Action Guides for emergency response for whole body external exposure to airborne radioactive materials and are summarized in Table 2-2. These guidelines represent numerical values as to when, under the conditions most likely to occur, intervention is recommended to avoid radiation exposure that would otherwise result from the incident. Due to the ability of the thyroid to concentrate iodines, the thyroid dose due to inhaling radioiodine

Table 2-2 Protective Action Guides for Whole Body Exposure to Airborne Radioactive Materials

Population at Risk	Projected Whole Body Gamma Dose (rem)
Nonessential personnel	1 to 5[a]
Emergency workers	25
Lifesaving activities	75

[a] When ranges are shown, the lowest value should be used if there are no major local constraints in providing protection at that level, especially to sensitive populations. Local constraints may make lower values impractical to use, but in no case should the higher value be exceeded in determining the need for protective action.

may be hundreds of times greater than the corresponding whole body external dose. The Protective Action Guide recommended by EPA for thyroid dose due to inhalation is shown in Table 2-3.

Within the framework of these guides, it is assumed that: (a) the PAGs apply to acute exposure from a gaseous cloud released to the atmosphere from a nuclear reactor accident; (b) the PAGs will not be applied to large communities (e.g., over 200,000 population) for which reasonable estimates cannot be made of evacuation times, evacuation distances, or the health risks related to massive movement of people; (c) the PAGs apply only to the taking of initial protective actions within the first 2 to 4 days after an accident, leaving decisions as to later protective actions or cessation of actions under specific situations to the responsible officials; and (d) insufficient information about the source term and probable duration of exposure preclude quantification of shelter as an effective protection action.

EPA Manual of Protective Action Guides and Protective Actions for Nuclear Incidents (34). This manual has been prepared to provide practical guidance to State, local, and other officials on criteria to use in planning for radiological emergencies that could present a hazard to the public. It is organized to provide a perspective for protective actions and guidance for planning and implementation of protective actions to protect the public in the event of a nuclear incident. This is followed by chapters dealing with Protective Action Guides for specific exposure pathways and time periods. The application of Protective Actions Guides and Protective Actions is being developed separately for various categories, such as (a) exposure from foodstuffs or water, (b) exposure from material deposited on property or equipment, (c) exposure to airborne radioactive materials, (d) foodstuffs and water contamination, (3) contaminated property or equipment, and (f) transportation incidents.

EPA has sent the draft PAGs and Manual for Protective Actions for Nuclear Incidents to other agencies, industry, and States for their use and comments.

PRICE ANDERSON ACT (1957)

The primary purpose of the Price-Anderson Act was to provide the public and the nuclear industry indemnification protection in the event of a major accident at a nuclear facility which caused public consequences, including personal injury and property damage. The "federal insurance" was necessary since there was no actuarial base on which to establish insurance needs or premiums. Since Price-Anderson establishes, in essence, "no fault" protection, an individual may recover damages

Table 2-3 Protective Action Guides for Thyroid Dose Due to Inhalation from a Passing Plume

Population at Risk	Projected Thyroid Dose (rem)
Nonessential personnel	5-25
Emergency workers	125
Lifesaving activities	(a)

(a) No specific upper limit is given for thyroid exposure since in the extreme case complete thyroid loss might be an acceptable penalty for a life saved. However, this should not be necessary if respirators and/or thyroid protection for rescue personnel are available as a result of adequate planning.

without having to resort to the tort system of determining liability for damages in the State courts. The law was enacted in 1957 and renewed in 1965. Until August 1, 1977, the protection provided by the present law is 560 million dollars--95 million by industry and 465 million by the government. In May 1974, the Joint Committee on Atomic Energy (JCAE) held hearings on the proposed legislation submitted by the AEC to modify and extend the provisions of the Price-Anderson Act. The bill (H. R. 15323) would extend the Act for five years with gradual phase out of government support.

President Ford vetoed an extension of the Act in October 1974 based on a technicality which he believed made the bill unconstitutional. This technicality was a part of an amendment, which would allow Congress to eliminate the provisions of the Act by resolution passed within 30 days after submission of a Joint Committee Report on the Reactor Safety Study (Rasmussen Report). In the President's view, he was, thus, expected to give his approval prior to Congressional approval, contrary to the procedures established by the Constitution.

SAFEGUARDS (16)

In its reviews of AEC Environmental Statements concerning plutonium utilization, EPA has commented that a commitment should be made to an acceptable safeguards program prior to initiation of a plutonium recycle program; and that such a safeguards program should be implemented prior to actual full scale mixed oxide fuel fabrication and fueling of light water reactors. In addition, the Council on Environmental Quality (CEQ) has suggested a number of steps it considers necessary to bring the safeguards proposals in the AEC generic environmental statement on mixed-oxide fuels (GESMO) into conformance with the National Environmental Policy Act.

In turn NRC provisional views indicated that its decision on whether to license wide-scale use of plutonium recycle fuel in light water reactors might not be forthcoming until mid-1978. This would permit development of draft and final environmental statements on alternative safeguards programs, including cost/benefit analyses, prior to approval of wide-scale use of such fuel. Many pro and con comments have been received by NRC and it appears that the procedures to be used in reaching a final decision on wide-scale plutonium recycle will be developed by NRC in 1975. The NRC provisional views were responsive to many concerns expressed, including those of EPA and CEQ.

NATIONAL POLLUTION DISCHARGE ELIMINATION SYSTEM

Under the Federal Water Pollution Control Act (FWPCA) of 1974, as amended, discharges of pollutants to navigable waters require a water permit to be issued by EPA. In a suit filed in the United States District Court in February 1974 for the District of Colorado by the Colorado Public Interest Research Group, Incorporated (plaintiffs) versus Russell Train, Administrator, Environmental Protection Agency, defendant, the plaintiff raised the legal issue that all radioactive effluents are subject to the regulations pursuant to the 1972 amendment to the FWPCA. The District Court ruled in favor of EPA. Subsequently, on appeal of the lower court decision, the United States Court of Appeals, Tenth Circuit on December 9, 1974 reversed the decision.

This case--known as the Ft. St. Vrain Nuclear Power Plant decision--has led EPA to a series of measures designed to develop a basis by which to comply with the decision, pending outcome of the appeal to the Supreme Court. For this purpose ORP will develop water effluent guidelines as required to comply with the court decision in support of the water permit program. This requires EPA to (a) issue permits in a timely manner, (b) ensure permit conditions reflect quality technical considerations, and (c) minimize duplication of Federal regulatory restrictions. Priorities for meeting these objectives have been established as a function of the magnitude of the impact, potential for delaying national energy requirements, availability of technical data, and the status of pending permit applications. Because of the court decision, first priority will be given to nuclear power reactors. Priorities for other facilities have been established and plans are being developed to implement the program for such facilities depending on resource allocation. This program also has the responsibility for monitoring and for assuring overall compliance. In addition, EPA may be required to list some radioactive materials as toxic substances under Section 307 of the Federal Water Pollution Control Act FWPCA) and designate such materials as hazardous under Section 311.

*In April 1975 the Solicitor General, on behalf of the Environmental Protection Agency and its Administrator, submitted a petition to the Supreme Court of the United States for a writ of certiorari to review the judgments of the United States Court of Appeals for the Tenth Circuit and subsequently the Supreme Court in June 1975 agreed to review these decisions.

ADVANCED REACTOR CONCEPTS

In addition to light water reactors and high temperature gas reactors there are several other reactor concepts that are being pursued. The concepts of nuclear energy centers (15) and offshore floating nuclear power plants are being investigated (16), as well as the use of Light Water Breeder reactors, gas cooled breeder reactors, molten salt breeder reactors, and fusion.

NUCLEAR ENERGY CENTERS (44)

The Nuclear Regulatory Commission is studying the nuclear energy center concept and is surveying and evaluating potential sites, as mandated by Section 207 of the Energy Reorganization Act of 1974. The survey is to be conducted in cooperation with other interested Federal, State, and local agencies. The views of interested persons including electric utilities, citizens groups, and others shall be solicited and considered [207(a)]. The survey shall include an evaluation of the environmental impact likely to result from construction and operation of such nuclear energy centers. The energy centers will include 10 to 40 reactors and associated fuel fabrication, fuel processing, and other facilities located within an area of 20 to 75 square miles. A report of the results is due to Congress and CEQ not later than one year from enactment, which would make it due October 1975.

OFFSHORE FLOATING NUCLEAR POWER PLANTS

This concept continues to be developed by Offshore Power Systems (16). This Westinghouse enterprise, formed in August of 1972 to design and manufacture offshore nuclear plants, has announced plans to build a completely new shipyard facility at Jacksonville, Florida. Floating nuclear plants would be constructed in the manufacturing facility on an assembly-line basis. An offshore floating nuclear power plant is basically a nuclear plant of standardized design constructed on a floating platform foundation in a shipyard type manufacturing facility. The completed plant would then be towed to a site possibly several miles from shore, and permanently moored inside a protective breakwater. An underwater cable would transmit the electric power from the plant to a shore distribution station. This plant concept avoids several problems of land based plants, but raises new questions of environmental safety and security. EPA is participating in the regulatory aspects of offshore floating nuclear power plants.

LIGHT WATER BREEDER REACTORS

The light water breeder reactor program is designed to confirm the capability of breeding in a pressurized water reactor through the in-plant testing of a breeder reactor core. The core is being designed and developed by Bettis Atomic Power Laboratory at Pittsburgh, Pennsylvania, under the naval reactors program of the AEC. Successful operation of the breeding core would show that it is feasible to install breeder cores in existing and future pressurized water reactor plants and would confirm the technology of breeding in a light water reactor using thorium. The core design employs a thorium-uranium-233 fuel system within a seed blanket core configuration to achieve breeding. Thorium is plentiful and easily available. By using it as the nuclear fuel material, light water breeder reactors, if successful, could substantially extend the nations energy resources.

Preparation of an environmental impact statement on the light water breeder reactor program is underway. Suggestions have been received regarding the content of the statement. The AEC has announced that a public hearing will be held following issuance of the draft environmental impact statement. The final statement will be issued before a decision is made to start operation of the Shippingport light water breeder reactor core.

OTHER REACTOR CONCEPTS

Molten Salt Breeder Reactor. The AEC has a limited basic technology program for the development of the Molten Salt Breeder Reactor. The molten salt breeder concept is a high-temperature, thermal-neutron breeder that would operate on the thorium-uranium-233 fuel cycle. The molten fuel salt consists of uranium and thorium fluorides dissolved in fluorides of beryllium and lithium. Continuous fuel processing is a basic feature of the system.

Work is continuing in the major areas of materials development, continuous fuel processing, and tritium (hydrogen-3) control. Oak Ridge Laboratory is responsible for a major portion of this research and industry is involved as required.

Fusion. All present nuclear power plant reactors use a fission process which entails the splitting of atoms (e.g., uranium or plutonium). An alternate source would be fusion power, which is achieved by harnessing the energy released by the merging of the nuclei of lightweight elements. A number of fusion reactions are known. However, the reaction of the hydrogen isotopes deuterium (hydrogen-2) and tritium (hydrogen-3) is regarded as the most likely basis for the first commercial fusion power plants. The isotope deuterium is in essentially unlimited supply in the world's rivers and oceans. The processes by which it may be extracted are well known. Tritium is not found naturally and must be created by a breeding process (neutron absorption in lithium). The fertile resource, lithium--the lightest known metal--is also available in large supply. Hence, availability of the basic fuel is not a matter of concern.

The AEC supports two programs (16) intended to employ the nuclear fusion process for civilian electrical power production. The controlled thermonuclear research program involves the use of magnetic fields to confine the reacting fuel. The laser fusion research program emphasizes the use of high-energy, short-pulsed lasers focussed on a suitable thermonuclear target. In the United States, KMS Industries, Incorporated independently sponsors a laser fusion program (14). There are a few other private research groups (Lawrence Livermore Laboratory, Los Alamos Scientific Laboratory, and Sandia Laboratories) working on such programs; these are government sponsored.

Besides realizing substantial progress during recent years, creators of current concepts for fusion power plants foresee low environmental impact. Fusion power plants will not have many of the potential environmental problems associated with nuclear fission reactors. Long-lived fission products will not be produced in a fusion power reactor and designs will reduce the generation of significant quantities of neutron activation products. However, they will be produced in the structural components in large quantities. These parts will have to be periodically replaced due to the high energy neutron flux effects. Nuclear runaway is not possible and reactor meltdowns can be avoided because of the low latent heat content in the fuel, containment wall, and shielding.

OTHER NUCLEAR APPLICATIONS

NUCLEAR WEAPONS TESTING

The major issue concerning nuclear weapons testing is the continued atmospheric testing by countries not signatory to the Test Ban Treaty, as well as the underground testing by any party. On July 3, 1974, the United States and the Soviet Union signed a treaty on the limitation of underground nuclear tests. If ratified by Congress, beginning March 31, 1976, each country will be restricted to conducting tests having a yield of less than 150 kilotons.

The United States and the Soviet Union have not conducted atmospheric tests since 1962, but a small portion of the remaining radioactive materials which had been introduced into the stratosphere from pre-1963, large-scale, high-yield tests is still deposited annually, and the measured low levels in the environment have become constant. The French and Chinese have continued to conduct atmospheric tests and have added small but measurable quantities of fallout in the continental United States. Underground testing programs were continued on the part of the United States and the USSR, while one was initiated by India in a 1974 detonation.

The detonations of nuclear devices have been used for both military and peaceful purposes. Those nuclear detonations detected and reported during 1974 (16, 42) are included in Table 2-4.

PEACEFUL APPLICATIONS OF NUCLEAR EXPLOSIVES

A number of possible uses of nuclear explosives have been suggested for industrial applications. These include excavation, natural gas stimulation, recovery of oil from oil shale, mineral recovery, underground storage, and waste and water management. Experimental programs in some of these areas have progressed to some extent, but in general the programs are in a hold status at the present time due to problems of economic feasibility, impact on the environment, and potential risk to consumers.

In the use of nuclear explosives for peaceful purposes, there is a question as to whether the environmental impact and risk of the nuclear program would be balanced by any benefits gained. Alternate (nonnuclear) methods of increasing the production of certain natural resources appear feasible. Another issue is the question of the levels of radioactivity in products produced through nuclear methods and consideration of the risk-benefit for consumers of these products.

The initial peaceful underground experiments, Projects Gasbuggy (El Paso Natural Gas Company, New Mexico, 1967) and Rulison (Austral Oil Company, Colorado, 1969), which were technologically successful, were followed by the Project Rio Blanco gas stimulation experiment with three simultaneous detonations on May 17, 1973, in western Colorado. The three 30 kiloton nuclear explosives created a fracture system and three chimneys of broken rock which act as large underground gas collectors from which the natural gas can be produced. Unfortunately, the top two fracture patterns did not connect well enough to permit gas to flow from all three chimneys into the initial reentry well, thus requiring a second reentry well into the bottom chimney. This was completed in October 1974, and gas production from this zone is being

Table 2-4 Nuclear Detonations During 1974

Date (1974)	Country	Test Area/NAME	Yield Range (kilotons)
30 January	USSR	Semipalatinsk	20-200
27 February	US	Nevada/LATIR	20-200
15 May	USSR	Semipalatinsk	20-200
17 May	India	Rajaschar desert	20
30 May	USSR	Semipalatinsk	20-200
17 June	China	Lop Nor	20-1000
19 June	UK-US*	Nevada/MING BLADE	20-200
10 July	US	Nevada/ESCABOSA	20-200
14 August	US	Nevada/PUYE	20
14 August	USSR	Tazovskiy Peninsula	20-200
29 August	USSR	Novaya Zemlya	1000-3000
30 August	US	Nevada/PORTMANTEAU	20-200
26 September	US	Nevada/STANYAN	20-200
16 October	USSR	Semipalatinsk	20-200
2 November	USSR	Novaya Zemlya	3000-4000

*Test Conducted with AEC laboratory assistance.

evaluated. The flow tests and pressure build-up measurements are designed to determine the technical success of Project Rio Blanco, and to provide data for a determination of the economic viability of gas stimulation using nuclear explosives.

Future Plowshare experiments in the state of Colorado will require a permit from the Colorado Department of Public Health as required by Section 25-8-20, of the Colorado Department of Health, Water Quality Act, effective July 1, 1973, which establishes a permit system for nuclear, toxic, and radioactive wastes. Under this section it shall be unlawful for any person to discharge, deposit, generate, or dispose of any radioactive, toxic or other hazardous waste underground in liquid, solid, or explosive form unless the commission, upon application of the person desiring to undertake such activity and after investigation and hearing, shall have first found beyond a reasonable doubt that there will be no pollution resulting therefrom or that this pollution if any will be limited to waters in a specified limited area from which there is no risk or significant migration and that the proposed activity is justified by public need.

UNITED STATES NUCLEAR NAVY

Presently there are 106 nuclear submarines and five surface ships in the U.S. Navy with authorization for a total of 130 nuclear submarines and 12 surface ships, or approximately one-third of the active U.S. warships. These ships are being constructed at the rate of 2 or 3 per year. By 1978, the year the current SALT treaty expires, the Russians will have reached their limit of 62 modern nuclear ballistic submarines. No figures are available for the remainder of their nuclear fleet; however, construction is taking place at the rate of 10 per year. (10)

Available figures for 1973 showed that the total volume of water discharged by the U.S. Navy in restricted waters from 107 ships, 9 shipyards, 11 tenders and 2 shore bases was less than 25,000 gallons. This water contained less than 0.002 curies of radioactivity excluding tritium. The total tritium released into harbors within 12 miles was less than one curie. The solid wastes are packaged in approved containers and shipped to burial sites licensed by the USAEC (or by a State under agreement with the USAEC) in compliance with the Department of Transportation (DOT) and USAEC. In 1973 this amounted to 59,000 cubic feet and about 222 curies of radioactive material. (30) This solid waste becomes numbered among items destined for ultimate disposal; thus, it contributes to the waste management problem.

COMMERCIAL NUCLEAR POWERED SHIPPING

The application of nuclear power to commercial ships has been less than successful, primarily for financial reasons. These reactors have been shown to be relatively clean and operated with little environmental contamination; however, in Japan, during 1974, a major problem in the design of the reactor in a commercial Japanese nuclear ship caused great concern (shielding against neutrons).

RADIATION MONITORING

EPA'S ENVIRONMENTAL RADIATION AMBIENT MONITORING SYSTEM

Continuing surveillance of radioactivity levels is maintained through EPA's Environmental Radiation Ambient Monitoring System (ERAMS). This system was formed in July 1973 from the consolidation and re-direction of separate monitoring networks formerly operated by the U.S. Public Health Service prior to EPA's formation. These previous monitoring networks were primarily operated for measurements of fallout levels. They were then modified by changing collection and analysis frequencies, sampling locations; and by increasing the number of analyses for specific radionuclides. The emphasis of the current system is toward identifying trends in the accumulation of long-lived radionuclides in the environment, with specific analyses being made for uranium-234 and uranium-238, plutonium-238 and plutonium-239, carbon-14, tritium, strontium-90, and krypton-85. (45)

Table 2-5 provides a summary of the current status and historical perspective of ERAMS. The system requires over 7,000 individual analyses annually on samples of air, airborne particulates, deposition, surface and drinking water, milk, and bone from approximately 150 locations throughout the continental United States, Alaska, Hawaii, and U.S. territories. Samples are collected by State and local health agencies and forwarded to ORP's Eastern Environmental Radiation Facility (EERF) in Montgomery, Alabama for analysis. From 1960 until December 1974, the ERAMS results were published in Radiation Data and Reports and its predecessor, Radiological Health Data and Reports (1966-1971), and Radiological Health Data (1960-1965). This publication was terminated due to budgetary constraints in 1974.*

*ERAMS data is presently available from: Environmental Protection Agency, Eastern Environmental Radiation Facility, P.O. Box 3009, Montgomery, Alabama 36109.

Component Name	Current Status Number of Sampling Sites	Sampling Frequency	Analyses Performed	Frequency of Analysis	Previous Network	Initially Established	Latest Descrip. in RD&R
AIR MONITORING PROGRAM							
Gross Radioactivity and Deposition Component	20 active (c) 54 standby	semi-weekly	gross β (a) gamma-scan (b)	Semi-weekly	Radiation Alert Network	1956	Dec. 74
Deposition	20 active 54 standby	as rain occurs	gross β	daily as rain occurs		1956	Dec. 74
			gamma-scan*	daily as rain occurs		---	
			tritium	monthly comp.		1967	Aug. 74
			Pu-238, -239 U-234, U-238	March-May comp.		1974	--
Plutonium and Uranium in Air Component	20	semi-weekly	Pu-238, -239 U-234, U-238	quarterly (d) quarterly (d)	Plutonium in Air-borne Particulates	1965	Nov. 74
Krypton-85 in Air Component	12	semi-annually	krypton-85	semi-annually	No network but individual measurements from 1962	1973	Nov. 74
WATER ANALYSIS AND SAMPLING PROGRAM							
Surface Water Component	55	quarterly	tritium gamma-scan	quarterly annually (d)	Tritium Surveillance System	1964	Aug. 74
Drinking Water Component	76	quarterly	tritium gross α gross β gamma-scan radium-226 strontium-90	quarterly annually (d) annually (d) annually (d) annually (e) annually (f)		1970	Aug. 74
	20	quarterly	Pu-238, -239 U-234, U-238	annually (d) annually (d)	None		----

Table 2-5 EPA's Environmental Radiation Ambient Monitoring System (ERAMS)

	Current Status						
Component Name	Number of Sampling Sites	Sampling Frequency	Analyses Performed	Frequency of Analysis	Previous Network	Initially Established	Latest Descrip. in RD&R
WATER ANALYSIS AND SAMPLING PROGRAM (Continued)							
Interstate Carrier System	658 2/19/year	triannually	gross α gross β strontium-90 radium-226	triannually triannually triannually triannually	**Interstate Carrier Drinking Water Project**	**1960**	**Dec. 74**
MILK ANALYSIS PROGRAM							
Pasteurized Milk Component	65	monthly	gamma spectrometry[(g)] strontium-89,90 tritium	monthly annually[(d)]	**Pasteurized Milk Network**	**1960**	**Dec. 74**
Special Milk Analysis Component	9	monthly	carbon-14	annually[(d)]	**Carbon-14 in Milk**	**1965**	**Nov. 73**
HUMAN ORGAN PROGRAM							
Bone Analysis Component	varies	annually	stable calcium strontium-90	annually annually	**Human Bone Network**	**1961**	**Jan. 73**

LEGEND:

• If deposition exceeds gross beta of 15 nCi/m^2

(a) Field estimate and subsequent laboratory determination

(b) If gross beta greater than 10 pCi/m^3

(c) Activated if contaminating event occurs (e.g., atmospheric nuclear test in the Northern Hemisphere).

(d) Composite sample analyzed

(e) If gross alpha level exceeds 3 pCi/1

(f) If gross beta level exceeds 10 pCi/1

(g) For ^{131}I, ^{137}Cs, ^{140}Ba, K

Table 2-5 (Continued)

Because of the nationwide coverage and consistent sampling and analysis methods, the ERAMS data has been extensively used for comparison with data from the vicinity of nuclear facilities. The ERAMS is intended to provide long-term trend data for major airsheds, watersheds, and milk producing regions and, therefore, complements, rather than duplicates, localized programs around specific nuclear facilities conducted by State agencies and facility operators. The ERAMS is a dynamic system in that improvements are being made as the need for additional information arises. Currently, plans are being made to institute analysis for iodine-129 in milk and the feasibility of creating a national program to determine plutonium levels in soil samples is being investigated.

STATE RADIOLOGICAL MONITORING

Many states operate environmental surveillance programs to obtain data on levels of radiation in the environment from operations of nuclear facilities. This data is used to meet the needs of the States for assuring protection to the public health of their citizens.

The AEC continued to improve its methods of evaluating licensees' programs for controlling radioactive effluents and monitoring radioactivity in the environment. As part of this effort an independent measurements program was established through collaborative agreements with several States for their support in measuring radioactivity in effluents and plant environs. At the end of 1974, there were 19 states participating in this program covering essentially all the operating nuclear power reactors. They included Alabama, Arkansas, California, Colorado, Connecticut, Florida, Illinois, Maine, Maryland, Michigan, Minnesota, Nebraska, New Jersey, New York, Pennsylvania, South Carolina, Vermont, Virginia, and Wisconsin.

In January 1974, the state of Colorado and the Atomic Energy Commission entered into a memorandum of understanding (a new step in intergovernmental relations) to permit the state of Colorado formal access and participation in the on-going program of monitoring and analysis of liquid effluents discharged from the Commission's Rocky Flats Plant near Golden, Colorado. Underlying this arrangement is the fact that such effluents are presently discharged into waters of the State of Colorado. In entering into this memorandum of understanding, the State of Colorado and the AEC recognize their common objective of maintaining the radiological constituents of these effluents at the lowest practicable level, and they encourage the establishment of a cooperative program to observe these levels as an aid to providing better control of such effluents through available means. The parties further recognize that this memorandum of understanding does not create an entirely new arrangement where none before existed, but is a formalization and expansion of a working relationship between them which has been in effect for a number of years.

NUCLEAR FACILITY LICENSING MONITORING

Nuclear facilities licensed by the Atomic Energy Commission conduct environmental surveillance to determine the levels of radioactivity in critical environment pathways. Such surveillance involves, but is not limited to, collection and analysis of samples of air, water, milk, vegetation, and soil. The results of review of monitoring data indicate that radioactivity releases to the environment from licensed nuclear facilities have generally been low in comparison with the limits set in AEC regulations. In the case of nuclear power reactors in addition to environmental surveillance, the licensee reports semi-annually the quantities of specific radionuclides in the liquid gaseous effluents. This data is available for use by the licensee and other Federal and State agencies to estimate the population dose within 50 miles of the facility.

EPA FIELD STUDIES AT NUCLEAR FACILITIES

The Office of Radiation Programs conducts field studies at operating nuclear facilities to (a) develop measurement techniques, (b) validate dose computational models, (c) characterize effluents, (d) determine the ability of technology for control of nuclear wastes to meet design technical specifications, and (e) study waste disposal sites to determine the effectiveness of burial techniques to contain the waste materials.

CONNECTICUT YANKEE

At Connecticut Yankee's Haddam Neck Generating Station a joint EPA, AEC, and State field study was conducted to obtain data for use in validating a dose model for estimating the external, whole body cloud gamma dose to exposed populations. The study was intended to provide information on the (a) identity and amount of radionuclides in effluents, (b) influence of station operation on radionuclide discharges, (c) degree of dispersion or concentration of radionuclides in the environment, (d) relative importance of specific radionuclides and vectors in exposing population groups, (e) magnitude of radiation exposure in the environment, (f) applicability of various monitoring and measuring techniques, and (g) determine the ability of technology for control of nuclear wastes to meet technical design specifications.

OYSTER CREEK

The Oyster Creek Nuclear Power Plant at Toms River, New Jersey, was studied by a joint EPA/AEC field study team. The data were gathered for validation of a dose model that estimates the external, whole body cloud gamma dose to exposed populations. The study objectives were to (a) gain information on individual radionuclides in the effluent as a basis for developing recommended radiological surveillance programs, (b) evaluate programs associated with measuring discharged radionuclides and interpreting results in terms of radiation exposure, (c) observe the movement of critical radionuclides from the plant through the environment under routine conditions of station operation, and (d) determine the ability of the technology for control of nuclear wastes to meet technical design specifications.

QUAD CITIES NUCLEAR POWER STATION

A joint EPA/AEC study was conducted in the vicinity at the Quad Cities Nuclear Power Station during June through October 1974. The purpose of the study was to continue the previous study of the Iodine-131 air to milk pathway at a BWR nuclear power station begun in 1973. Measurements included (a) release rates of Iodine-131 by chemical species at the main chimney and vent, (b) air concentrations of Iodine-131 by species at four locations, (c) Iodine-131 concentrations in grass at five locations, and (e) Iodine-131 concentrations in milk at two locations. Measurement sensitivities were critical to this study and as such there were a limited number of samples with activities below the detection limit. A report of this study is presently in preparation.

COOPER NUCLEAR POWER STATION

A joint EPA/ERDA/NRC field study was conducted at the Cooper Nuclear Power Station in Brownville, Nebraska. A source of Nitrogen-16 dose at the reactor site is from moisture separators and turbines, which are both typically located on the same floor and shielded along a line of sight from ground-level location. The purpose of this study was to obtain Nitrogen-16 dose data at locations outside of the building boundaries. The doses at such locations are from skyshine (large angle air scatter) rather than directly from the Nitrogen-16 source itself as had been the case in previous studies. The data were needed to provide a check on the complex models that are used to predict such doses as a technical input into the proposed Uranium Fuel Cycle Standard.

MONTICELLO NUCLEAR GENERATING PLANT - DOSE MODEL VALIDATION STUDY (16)

A joint EPA/AEC field study was conducted at the Monticello Nuclear Generating Plant to obtain data for use in validating a dose model for estimating the external, whole body cloud gamma dose to exposed populations. The model--after validation--will be useful in estimating dose to the population at other boiling water reactors with similar site and construction characteristics.

Participants in the study included the Eastern Environmental Radiation Facility; the Meteorological Division, Research Triangle Park; representatives from the Field Operations Division--Operations Analysis Branch; Minnesota Department of Health; Northern States Power Company; and the AEC. A report is expected to be published by mid-1975.

G.E. FUEL FABRICATION PLANT

A field study was initiated in early 1974 at the G.E. Fuel Fabrication Plant north of Wilmington, North Carolina (16). The plant was chosen as being typical of the larger fuel fabrication facilities. The purpose of the study was to characterize the stack effluents and to acquire data from environmental surveillance at a facility on types of radionuclides discharged and significant environmental exposure pathways. This data will be used to validate dose models (and source terms) for use in future estimates of individual and population doses from normal operation of the plant.

FIELD STUDY AT OCEAN DUMPING SITES

EPA has a specific regulatory requirement to control oceanic disposal of radioactive wastes under P.L. 92-532, the Marine Protection, Research and Sanctuaries Act. In order to fulfill these responsibilities, the Office of Radiation Programs is conducting oceanographic investigations in two former radioactive waste dumpsites, one located off the east coast, the other off the west coast, to learn the long-term fate of the containerized radioactive wastes. From this will be developed more detailed regulations and criteria governing any possible requests for permits for specific dumping operations.

LEGISLATION

One aspect of the licensing procedure which has gained special emphasis is that of power plant siting. This has become an increasingly important subject for state legislation over the past several years. When the Southern Interstate Nuclear Board (SINB) first published "Power Plant Siting in the United States, 1972--A State Summary," only about five states had officially enacted siting laws. As of September 8, 1974*, eighteen states have passed such legislation and a significant number of jurisdictions will act during their 1975 legislative sessions.

Another aspect of legislative action deals with nuclear energy. In 1974 a total of 11 Federal bills dealing with nuclear energy were defeated with no bills being passed. Five of these bills were introduced in 1973. (6) At the state level, 42 bills dealing with nuclear energy were acted upon. These bills were either introduced or carried over from 1973. A total of 7 bills were passed by 6 states. The comparative figures for state legislation on nuclear energy in 1973 show 10 bills approved from a total of 44 bills acted upon (7).

RESEARCH FOR RADIOLOGICAL PROTECTION

ENVIRONMENTAL PROTECTION AGENCY

The Environmental Protection Agency's Office of Research and Development pursues a scientific research effort in support of the needs defined by ORP. The purpose of these investigations is to eliminate many of the uncertainties associated with health effects and environmental processes that currently affect environmental radiation protection. In addition, the policy studies are directed toward evaluating technical radiation control alternatives and overall program alternatives. It is anticipated that results of these studies will direct the Agency's future radiation program thrusts and also point out specific areas where legislation is needed.

The scientific research program, while conducting both non-ionizing and ionizing radiation studies, will have its thrust in two major areas. The first is health effects research, which will be primarily directed toward the establishment of definitive knowledge in the area of non-thermal health effects and toward the investigation of specific health effects questions regarding key radionuclides, such as plutonium and actinides. The second is ecological processes and environmental transport. Work in this area is necessary to reduce the uncertainties in migration patterns, resuspension factors, and other general pathway parameters. With these uncertainties reduced, more definitive action can be taken with respect to these materials.

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*This compilation was done by the Southern Interstate Nuclear Board and is current as of September 8, 1974.

This research is carried out at NERC--Research Triangle Park, at NERC--Las Vegas, and by contract.

ATOMIC ENERGY COMMISSION

AEC is the major research agency dealing with the problems of nuclear energy and radiation protection. Under the Reorganization Plan of 1974, which established the Energy Research and Development Administration (ERDA) this role has been taken over and expanded to include other facets of energy development. The primary objective of AEC's (ERDA's) research program in the radiation area is to ascertain the quantitative and qualitative health and environmental effects from any step in the nuclear fuel cycle. This includes steps from resource recovery to waste management operations. AEC's (ERDA's) program also includes continuation of important, high priority work in support of nuclear energy technology development. The AEC (NRC's) Office of Nuclear Regulatory Research conducts research relevant to the needs of NRC. The Office develops plans and policy options which are subject to Commission review and actions relevant to the research necessary for the performance of the licensing functions in both reactor and fuel cycle radiological safety areas. The research programs are conducted through contracts with national laboratories and other groups. The NRC research program sponsors the Rasmussen Study (WASH-1400) the principal program investigating the probability of accidents and their consequences in light-water reactors. Included are research efforts investigating the Liquid Metal Fast Breeder Reactor (LMFBR), High Temperature Gas Cooled Reactor (HTGR), and programs on safeguards, facility safety, waste management, radioactive materials, transportation, and environmental effects of nuclear power. EPA maintains close liaison with the research being carried out, in order to be cognizant of ERDA's and NRC's efforts and to avoid duplications.

INTERNATIONAL ORGANIZATIONS AND ACTIVITIES (16)

The AEC has had a consistent policy of sharing nuclear safety information with other countries. Today, as more nuclear facilities are being built in foreign countries, two international objectives are becoming more important to the U.S. regulatory organization. First, the U.S. needs to benefit from the nuclear experience being accumulated elsewhere. We must, for example, be made aware promptly of the technical and political implications of nuclear reactor problems experienced in other countries. Second, it is important that the benefits of increasing safety research being conducted especially by nations with advanced programs, be available to help assure the safe use of energy worldwide.

International activities to meet these objectives include formal arrangements for the reciprocal exchange of information and cooperation in standards work, visits by and assignments of foreign regulatory employees to the AEC regulatory organization, reciprocal notification of important regulatory decisions, and foreign visits by the U.S. regulatory staff.

INFORMATION EXCHANGE ARRANGEMENTS

While almost all documentary material on the U.S. regulatory program is available to the public, some countries require that any information the government regulatory authority gains in its official duties remain the property of the owner of the licensed facility, and it is unlawful for their governments to release such information without a formal international agreement. Even with routine disclosure of U.S. regulatory information, foreign authorities still frequently need assistance on technical matters and prompt advice concerning important events in the U.S.

In order to formalize reciprocal exchanges of regulatory information to assure that the U.S. receives news of important foreign developments, the AEC has negotiated bilateral exchange arrangements with the countries that have significant programs for the construction and operation of light water reactors. During 1974, such agreements were signed with the nuclear regulatory agencies of Japan, France, Spain, Sweden, and Switzerland. They provide for systematic reciprocal exchanges of data on operating experience and other technical information related to the safety and environmental impact of nuclear power plants. They also lay the groundwork for cooperation in the development of nuclear safety standards.

Negotiations on additional information exchange agreements are being held with other countries. By the end of 1975, the AEC hopes to have such agreements in effect with all the countries that have major nuclear power programs.

VISITS OF FOREIGN NATIONALS

In mid-1974 the AEC began a small scale program of assigning a limited number of foreign regulatory employees from countries just starting nuclear power programs to work for one to two years within the AEC regulatory organization. In this carefully controlled program, AEC expects 8 to 10 foreign experts to work with the U.S. staff, gaining knowledge and experience which will assist in the future organization of their national regulatory programs. To date, two such foreign experts (from Australia and Denmark) are working in the Licensing Directorate. Several additional assignments of this type are under consideration.

The regulatory staff also received directly and through the IAEA an increasing number of foreign visitors, 223 in 1974. The staff also received requests for information about the U.S. policy of licensing and regulation, and about decisions on specific technical or procedural matters. This task will continue to grow as more reactors are built overseas and more governments start programs of nuclear energy regulation.

NOTIFICATIONS OF IMPORTANT EVENTS

The AEC has begun a practice of prompt notification to interested foreign governments of each important AEC decision affecting the construction or operation of nuclear power plants in the U.S. Seventeen such notifications were dispatched to 16 countries and two international organizations in 1974, usually within hours of the public announcements. This openness with other countries has resulted in additional information being sent to the U.S. in exchange.

INTERNATIONAL ATOMIC ENERGY AGENCY

The AEC continued its support of the International Atomic Energy Agency's program in the field of nuclear safety and issued a resolution supporting the Agency's expanded program to develop internationally acceptable safety codes and guides. The U.S. is prepared to make important contributions, including expert services without cost, to the International Atomic

Energy Agency (IAEA) to help accomplish the objectives of this program. The development of a set of standards for commercial light water reactors, which would permit the IAEA to give advice and assistance to developing nuclear states on a uniform and consistent basis, is expected to take several years. Because of the U.S. leadership position in nuclear standards, the U.S. regulatory organization is expected to provide various participants through the duration of this program.

OUTLOOK FOR THE FUTURE

The historic growth rate for nuclear power changes during 1974. This was partly due to a decrease in a demand for electric power as generated by an economic recession, and by pleas for conservation. Another major factor is the inflationary process which has placed many utilities at a disadvantage in regard to raising new capital. The time delay for getting an EIS approved is also a factor. By the end of September 1974, electric utilities had deferred construction of 70 previously ordered reactors, and had cancelled plans for nine nuclear units previously ordered. It is evident, then, that the potential nuclear power generation capacity will not meet earlier projected levels.

It appears that the decline in orders (and construction) for nuclear power plants will continue into 1975. On the basis of information available it appears that only 9 or 10 firm orders will be placed in that year. The bar chart below, Figure 2-2, gives the story.

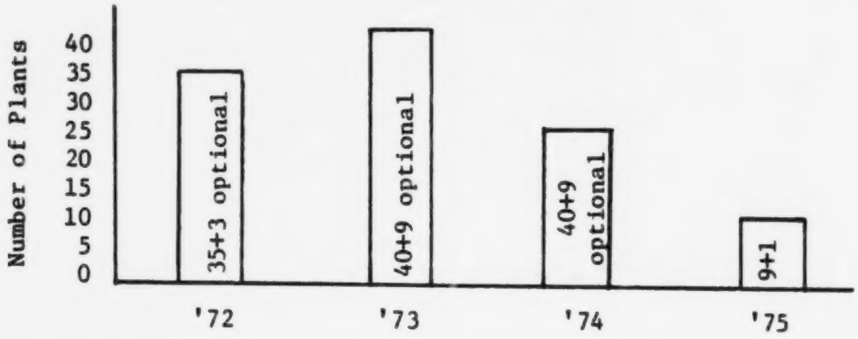

Figure 2-2 Nuclear Power Plant Sales (1972-5)

The major factors presently affecting plant availability were scheduled shutdowns for refueling and maintenance operations, unscheduled outages for replacement or repair of malfunctioning valves and switches, replacing turbine generators, and correction of problems with steam generators. In addition, plant shutdowns of various lengths of time were caused by failure of electric motors, pipe leaks, failures in electronic circuitry and monitoring equipment, excessive vibrations, failure of hydraulic shock and sway arrestors, and personnel or procedural errors. Most of these factors will continue to affect plant operations in the future.

At present there are no spent fuel reprocessing plants operating in the United States. It does not appear that there will be an operating plant until about 1978. Delays in start-up at reprocessing plants, and the possibility that future capacities of facilities will not keep pace with demand, imply that a shortage in spent fuel storage capacity could develop. Therefore, concentrated effort is needed to solve the future transportation and ultimate storage problems for the vast amounts of radioactive wastes that are being generated.

An acceptable model for evaluating the impact and determining the suitability of long term waste disposal methods will have to be adopted. Delays in adoption of a disposal model will extend the time for adoption of at least one ultimate disposal method. It is anticipated that eventually several long term disposal methods will be acceptable.

The problem of reactor safety will be a continuing focal point. The Rasmussen report has and will continue to receive a great deal of attention. Various Federal Agencies and environmental organizations have attacked various aspects of this study. Although it will be impossible to satisfy all people with regard to the safety aspects of nuclear power, there appear to be certain areas of research in this study that deserve further investigations. Such reactor safety research should also consider the new types of reactors being considered.

The entire nuclear fuel cycle will be under scrutiny for some time to come to determine the potential for accidents and acceptable levels of risk. Consideration will be given to accidents affecting the population at large and the environment, and to accidents and working conditions which affect plant personnel.

REFERENCES

1. Federal Energy Administration, Project Independence, A Summary, U.S. Government Printing Office, Stock Number 4118-00028, November, 1974 (There are also 10 volumes in the main report).

2. General Services Administration, "Responsibilities of Federal Agencies for Fixed Nuclear Facilities Incident Planning," Federal Register, Volume 38, Number 16, January 24, 1973.

3. International Commission on Radiation Protection, "Implications of Commission Recommendations That Doses Be Kept As Low As Readily Achievable," ICRP Publication Number 22, April 1973.

4. Letter to Dr. S.H. Smily from the Environmental Protection Agency dated November 21, 1974.

5. Meyer, G.L., "Maxey Flats Radioactive Waste Burial Site," Personal Letter dated February 19, 1975.

6. Miller, L.A., Federal/State Radiation Control Legislation 1974, DHEW Publication (FDA) March 1975.

7. Miller, L.A., Federal/State Radiation Control Legislation 1973, DHEW Publication (FDA) 74-8023, March 1974.

8. National Academy of Sciences/National Research Council, The Effects on Populations of Exposures to Low Levels of Ionizing Radiation, Report of the Advisory Committee on the Biological Effects of Ionizing Radiation (BEIR Report), NAS/NRC report, November 1972.

9. "Nuclear Electricity Generation," Nucleonics Week, January 24, 1974.

10. Rickover, Admiral H. G., "Naval Nuclear Propulsion Program, 1974, Hearing before the Joint Committee on Atomic Energy," 93rd Congress of the United States, Second Session, Testimony given February 25, 1975.

11. Rowe, W.D., Ph.D., "Liquid Metal Fast Breeder Reactor Policy Approach," Letter to Roger Strelow, March 21, 1975.

12. Rowe, W.D., Ph.D., "Waste Disposal: The Ultimate Question," Presented at the Waste Management '75 Symposium, Tucson, Arizona, March 24, 1975, U.S. Environmental Protection Agency, Office of Radiation Programs report.

13. Schneider, K.J., and Platt, A.M., Editors, Advanced Waste Management Studies, High-Level Radioactive Waste Disposal Alternatives, U.S. AEC Report BNWL-1900, Battelle, Pacific Northwest Laboratories, Richland, Washington, 4 Volumes, May 1974.

14. Siegel, Keeve M., "Laser Fusion Program: Statement before the Subcommittee on Legislation of the Joint Committee on Atomic Energy on March 13, 1975.

15. Tamplin, A.R., and Cochran, T.B., Radiation Standards for Hot Particles, National Resources Defense Council Report, February 1974.

16. U.S. Atomic Energy Commission, 1974 Annual Report to Congress, 94th Congress, 1st Session, Senate Document Number 94-2, January 17, 1975.

17. U.S. EPA, Draft Environmental Statement Comments: Management of Commercial High-Level and Transuranium-Contaminated Radioactive Waste (WASH-1539) AEC document D-AEC-A-00107-00 November 1974.

18. U.S. EPA, Draft Environmental Statements Comments: Liquid Metal Fast Breeder Reactor Program, AEC document D-AEC-A00106-00, August 1974.

19. U.S. Atomic Energy Commission, Draft Environmental Statement: Management of Commercial High-Level and Transuranium-Contaminated Radioactive Waste, AEC report WASH-1539, September 1974.

20. U.S. Atomic Energy Commission, Draft Environmental Statement: Waste Management Operations Hanford Reservation, Richland, Washington, AEC report WASH-1538, 3 Volumes, September 1974.

21. U.S. Atomic Energy Commission, Draft Generic Environmental Statement on the Use of Mixed Oxide Fuels in Light Water Reactors, AEC report Wash 1327, August 1974.

22. U.S. Atomic Energy Commission, Final Environmental Statement Concerning Proposed Rule Making Action: Numerical Guide for Design Objectives and Limiting Conditions for Operation to Meet the Criterion "As Low As Practicable" for Radioactive Material in Light-Water-Cooled Nuclear Power Reactor Effluents, Volume 1, The Statement, AEC publication Wash-1258, July 1973.

23. U.S. Atomic Energy Commission, High-Level Radioactive Waste Management Alternatives, AEC report WASH-1297, May 1974.

24. U.S. Atomic Energy Commission, "Licensing of Production and Utilization Facilities: Light-Water-Cooled Nuclear Powered Reactors," (Proposal), Code of Federal Regulations Title 10, Part 50, Appendix I, proposed in Federal Register Volume 36 FR 11113, June 9, 1971.

25. U.S. Atomic Energy Commission, Draft Environmental Statement: Liquid Metal Fast Breeder Reactor Program, AEC report WASH 1535 (4 Volumes) March 1974.

26. U.S. Atomic Energy Commission, The Nuclear Industry 1974, AEC report WASH 1174-74.

27. U.S. Atomic Energy Commission, Nuclear Power Reactors in the United States, AEC Release, December 31, 1974.

28. U.S. Atomic Energy Commission, Plutonium and Other Transuranium Elements: Sources, Environmental Distribution and Biomedical Effects, AEC report WASH-1359 on Testimony before an Environmental Protection Agency hearing board, December 10-11, 1974.

29. U.S. Atomic Energy Commission, Reactor Safety Study, An Assessment of Accident Risks in the U.S. Commercial Nuclear Power Plants, AEC report WASH-1400 (Draft), August 1974.

30. U.S. Department of the Navy, Environmental Monitoring and Disposal of Radioactive Waste from U.S. Nuclear Powered Ships and Their Support Facilities, Naval Sea Systems Command, USN report NT-74-1, Washington, D.C., April 1974.

31. U.S. Environmental Protection Agency, Approaches to Population Protection in the Case of Nuclear Accidents, Office of Radiation Programs, Draft, November 1974.

32. U.S. Environmental Protection Agency, The Comparative Risk Perspective for Setting Protective Action Guides, Office of Radiation Programs, Draft, January 1975.

33. U.S. Environmental Protection Agency, Draft Environmental Statement a Proposed Rulemaking Action Concerning Environmental Radiation Protection Requirements for Normal Operation of Activities in the Uran-Fuel Cycle, Office of Radiation Programs, December 1974.

34. U.S. Environmental Protection Agency, Draft Manual of Protective Action Guides and Protective Action for Nuclear Incidents, Office of Radiation Programs document EPA-520/1-75-001.

35. U.S. Environmental Protection Agency, Emergency Response Protective Action Guides Airborne Releases from Fixed Nuclear Facilities, Office of Radiation Programs, January 1975.

36. U.S. Environmental Protection Agency, Environmental Analysis of the Uranium Fuel Cycle, Parts I, II and III, Office of Radiation Programs publication EPA-520/9-73-003 (B, C, D), October 1973.

37. U.S. Environmental Protection Agency, "Environmental and Public Health Protection from Radioactive Effluents: Guidelines," Federal Register, Volume 39, Number 92, May 10, 1974.

38. U.S. Environmental Protection Agency, Environmental Radiation Dose Commitment: An Application to the Nuclear Power Industry, ORP Publication EPA-520/4-73-002, June 1974.

39. U.S. Environmental Protection Agency, National Radiation Protection Program Strategy, Office of Radiation Programs document EPA-520/7-75-007, (In Press) May 1975.

40. U.S. Environmental Protection Agency, "Notice of Intent to Review the Need for Establishing New Rules for Plutonium and Transuranium Elements," Federal Register, 20 FR 24098, September 23, 1974.

41. U.S. Environmental Protection Agency, Public Meeting Between Atomic Energy Commission and Environmental Protection Agency on Liquid Metal Fast Breeder Reactor, Environmental Impact Statement (WASH-1535), EPA report, August 13, 1974.

42. U.S. Environmental Protection Agency, Radiation Data and Reports, Volume 15, Numbers 1-12, 1974.

43. U.S. General Services Administration, "Nuclear Incident Emergency Planning--Fixed Facilities and Transportation: Notice of Interagency Responsibilities," Draft prepared by the Office of Preparedness, March 17, 1975.

44. U.S. Nuclear Regulatory Commission, Nuclear Energy Center Site Survey, Office of Special Studies report NUREG-75/018, March 13, 1975.

45. Nuclear Safety Volume 16, Number 6, EPA Environmental Assessment Program.

CHAPTER 3
NATURALLY-OCCURRING RADIOACTIVITY

INTRODUCTION

The largest source of ionizing radiation exposure to the world's population is radiation from the natural environment. Man has been continuously exposed to natural radiation sources for thousands of years. This exposure is not uniform for all individuals, but varies with such factors as altitude, geological features, and man's living habits. For example, cosmic radiation intensity increases threefold from sea level to 10,000 feet, and by 10 to 20 percent from 0 degrees to 50 degrees geomagnetic latitude (6).

The existence of natural radiation sources is not the direct result of man's activities. Exposure to external natural radiation sources occurs through cosmic radiation and radioactive elements originating in the earth's crust. An additional increment of external exposure, which accounts for a small percent of the total, is due to the presence of the radioactive decay products of radon and thoron in the atmosphere. Internal exposure to natural radiation sources is due to inhalation and ingestion of foods, liquids, and air containing naturally occurring radionuclides. The intensity of natural radiation sources can be enhanced by some technological activity by man that is not expressly designed to produce radiation (3). That is, exposure from natural radioactivity can be increased and concentrated by man's industrial and other activities. Examples of this type of natural radiation sources are uranium mill tailings, radioactivity in construction materials, uranium in fertilizers, and cosmic radiation exposure due to air travel (3). Consequently man increases his exposure from these sources of natural radiation by means of his technology and his lifestyle.

Naturally occurring radionuclides have always made a significant contribution to man's external radiation exposure, and they will continue to do so in the future. In many areas of the United States, the magnitude of terrestrial radiation exposure is relatively uniform. However, significant variations from the average exist in some regions due to high concentrations of uranium, thorium, and their decay products in soil, building materials, and other media. Potassium-40 and the radioactive decay chains of uranium-238 and thorium-232 are radionuclides which contribute most significantly to man's exposure. Many additional radioactive nuclides do exist but due to their half lives, energies, and low abundance they have an insignificant dose equivalent to man.

In a given location, the exposure to terrestrial radiation is primarily determined by the soil concentration of natural radionuclides (6). Exposure from terrestrial sources of radiation is generally considered unavoidable; however, it may be partially controlled by appropriate land use in particularly radioactive areas and in areas where man has altered the environment.

Another major component of natural radiation exposure to the population is cosmic radiation. Cosmic radiation is composed primarily of galactic radiation and a varying component of solar radiation. With the exception of short-term variations in cosmic ray intensity, there is no evidence to indicate the occurrence of significant changes in the intensity of cosmic radiation since the most recent magnetic field reversal some 700,000 years ago.

Various factors contribute to cosmic radiation variations and explain the rather large differences in the reported measurements. Time variations of cosmic radiation have been observed and are generally thought to be attributable to the solar influence on the interplanetary magnetic field. These variations occur in regular cycles and result in variations in cosmic ray intensity of approximately 10 percent.

Another factor which influences cosmic radiation variations is latitude. This effect is a result of the earth's geomagnetic field which tends to eliminate low energy cosmic particles. However, the overall influence of latitude on cosmic radiation exposure within the United States can be considered small. Other factors which influence cosmic radiation exposure are altitude and barometric pressure. For purposes of long term estimating, the variations are not significant. Variations of cosmic radiation with latitude and altitude are shown in Figures 3-1 and 3-2.

Even the most recent measurements of cosmic radiation differ by large percentages. These differences have been explained by instrumentation construction, calibration techniques, and radon daughters in the atmosphere.

In addition to terrestrial and cosmic external radiation sources, radiation exposure can result from ingestion and inhalation of natural radionuclides. The major contributor by inhalation is radon and its

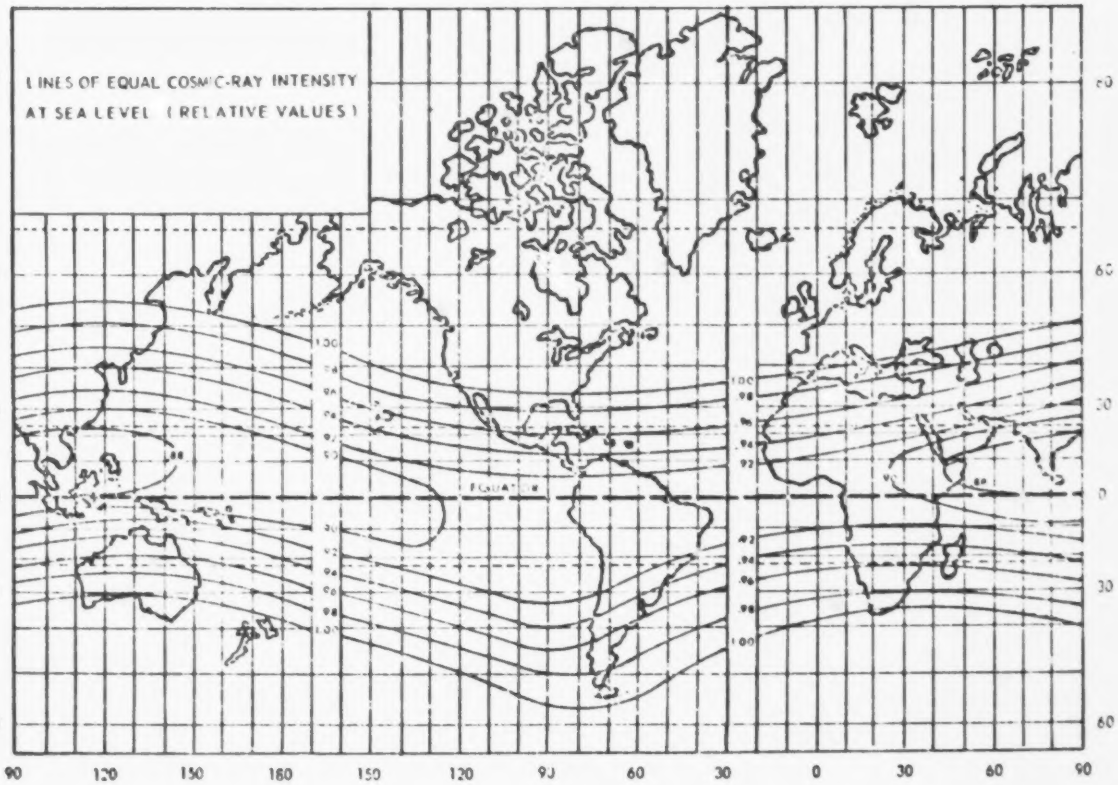
LINES OF EQUAL COSMIC-RAY INTENSITY
AT SEA LEVEL (RELATIVE VALUES)
EQUATOR
100
98
96
94
92
90
80
60
30
0
30
60
90
120
150
180
150
120
90
60
30
0
30
60
90

Figure 3-1 Variation of Cosmic Radiation with Latitude (Millikan, 1936)

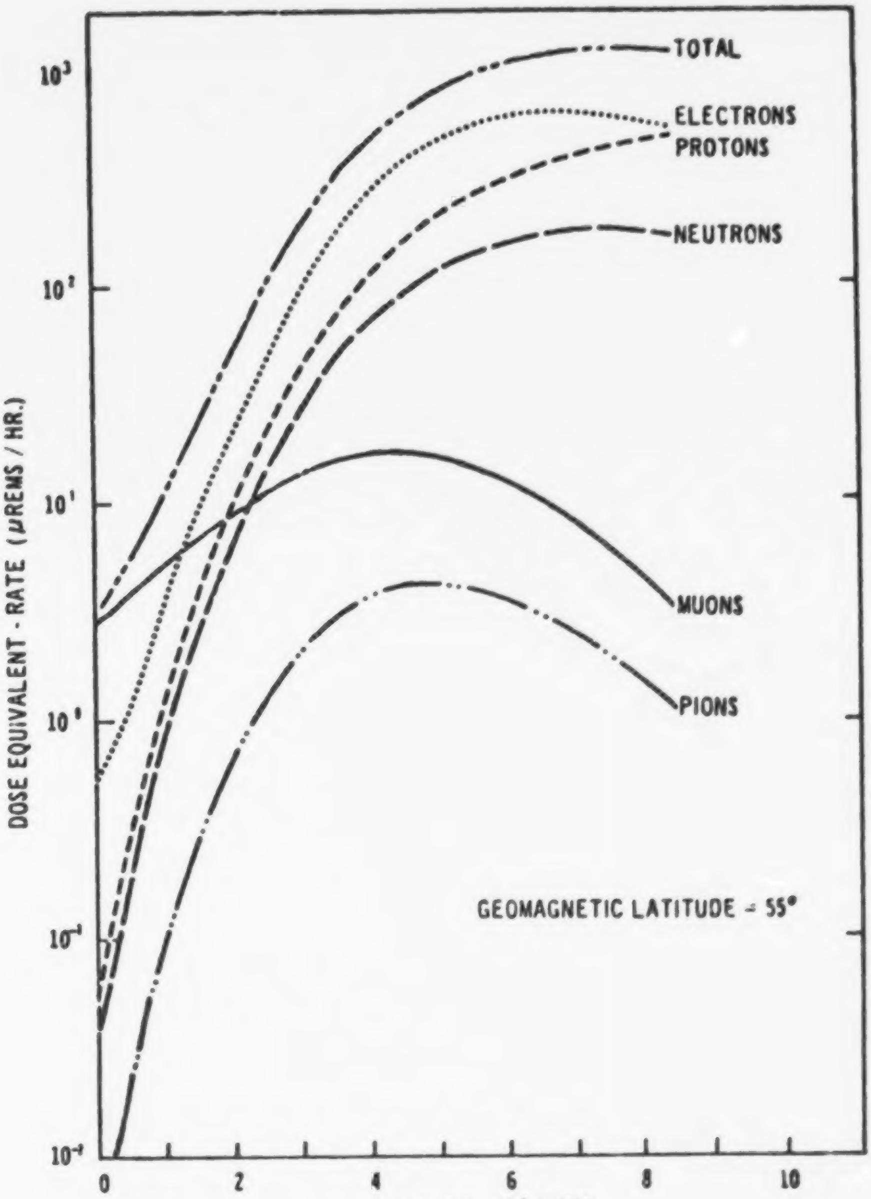

Figure 3-2 Cosmic Ray Dose Equivalent Rate Variation With Altitude (O'Brien and McLaughlin, 1970)

daughter products, and by ingestion mostly potassium-40. Other significant internal emitters are radium-226, radium-228, and their daughter products. The primary sources of lung dose exposure to the general population is radon, thoron, and their decay products.

Although the quantity and intensity of natural radiation sources has remained constant in recent times, man's living habits have changed in ways that influence exposure. Substantial populations have migrated from coastal to inland areas, thus increasing their elevation and exposure to cosmic radiation. Also, society has tended to move from an outdoor rural life to an indoor life in urban centers. Thus, man's exposure in some instances has been increased because of the natural radioactivity in some building materials. On the other hand, some buildings reduce exposure to the outdoor terrestrial sources and therefore, depending upon the construction materials, a building may either reduce or increase exposure.

As man seeks to improve his standard of living and demands greater use of available natural mineral resources, the earth's protective crust is broken and the naturally occurring radioactive ores are processed increasing potential exposure to the population. Many industries mine and process raw materials which are found in strata containing significant concentrations of uranium, thorium, and their daughter products. This includes well established industries such as the phosphate industry, rare earth, and several other mining industries, as well as newer, less developed industries such as oil shale and geothermal power.

When the naturally occurring radioactive materials are confined to depths of the earth, they have little impact on man or the environment due to the shielding effect of the ground cover. However, when ore is mined, separated, processed into commercial products, and distributed, individuals and large populations can be subjected to exposure from the radioactive components.

These radioactive materials can affect man and the environment in four basic ways. First, gaseous and particulate radioactive materials are released to the air, becoming available for possible human inhalation and lowering the overall air quality. Second, the radioactive materials in the ores or the associated by-products can enter ground and surface waters by effluents discharges, land runoff, and leaching from waste piles. A third effect is caused by the close contact of workers with the radioactive material. The fourth potential impact is contamination of the food chain, which may result in man's ingestion of radioactive materials.

From the standpoint of man's exposure, only potassium-40, and the radioactive decay chains of uranium-238 and thorium-232 are significant.

Potassium-40 occurs as one of three potassium isotopes. The two most abundant isotopes, potassium-39 (93.1 percent) and potassium-41 (6.9 percent), are stable. The third isotope, potassium-40 (0.0118 percent) decays with a half life of a billion years. As potassium-40 decays, gamma rays are emitted creating a source of exposure to man.

Uranium-238 and thorium-232 decay through a series of radionuclides to radon-222 and radon-220 respectively. Because of the shorter half life of radon-220, there is less opportunity for diffusion from the ground, and thus airborne concentrations of radon-222 are generally two orders of magnitude greater than those of radon-220.

Substantial environmental and public health problems associated with natural radioactivity are emerging which require for their solutions effective regulatory roles in Federal agencies and in the States. The major problem areas have been identified for successfully addressing the issues. Many of these areas have been the subject of extensive Environmental Protection Agency activity over the past year. Other areas will require intense involvement in the near future. In general, these areas call for environmental assessment and the development of adequate control measures to minimize any public health risk from naturally-occurring radioactivity.

MAJOR ENVIRONMENTAL RADIATION PROTECTION ACTIVITIES

URANIUM MINE AND MILL TAILINGS

Large scale milling of uranium ore began in the United States in the late 1940's. The average time of operation of a uranium mill has been 12 to 15 years. There are currently more than 20 inactive mills. Each location where a mill is operating or has operated has an accumulation of waste products or tailings. As of 1970, there were more than 80 million metric tons of tailings occupying more than 2,100 acres of land. In recent years, there has been a sharp increase in the use of light-water-cooled nuclear reactors to generate electricity. There has been a parallel growth in the uranium fuel industry that provides the enriched uranium fuel for these operations.

The radioactivity in uranium ores depends primarily on the amount of uranium in the ore. Processes such as leaching by groundwater and diffusion of radon gas can also affect the amount of radioactivity in the uranium ore. The principal decay chain in the radioactive decay process for uranium ore is that beginning with uranium-238 and ending with lead-206. Most of the ores currently being mined are 0.1 percent or more uranium oxide. Generally, the ores are stockpiled near the mills and blended to provide a uniform feed of approximately 0.2 percent uranium oxide. During milling, 20 to 80 percent of the radon gas in the ore and small fractions of the other radionuclides are released to the environment. (13) Almost all the radioactive decay products of the uranium ore end up in the tailings, mostly in the tailings solids, but with small percentages in solution.

After the uranium is extracted from the ore, more than 99 percent of the ore material becomes the mill wastes or tailings. Included in these tailings are 97 percent of the radioactive decay products of the uranium and about 4 percent of the original uranium. (13) The tailing piles release radioactive material to the air as radon gas, as airborne particulates, and waterborne radionuclides leached out by precipitation, surface runoff, and the wastes solutions. Sufficient radioactivity is in the tailings to create a field of gamma radiation in the immediate vicinity of the tailings. Because of the presence in the tailings of thorium-230, which by its decay maintains the radium inventory, the radioactivity in the tailings will remain almost constant for thousands of years. While mills are in operation, most of the tailings are either saturated with water or under water in tailings ponds. The water inhibits the radon gas from escaping. When the milling operation is discontinued, the sands will partially dry. If the slimes have been segregated and not mixed with the sands, they may retain moisture longer.

In the milling operation, hazardous airborne gaseous and particulate wastes are generated from a number of different sources. These are mainly gaseous and particulate effluents from the ore crushing area, the fine ore bins, and the yellowcake packaging and drying area. Current practice involves the use of wet dust control systems forthe ore crushing area and fine ore storage bins and wet scrubbers with bag filters for the yellowcake packaging and drying areas. The scrubber efficiency for the ore crushing area is about 95 percent, and for the yellowcake packaging and drying areas it is 99 percent. (13)

Other sources of gas and dust which can be controlled are open pit mine haul roads and the ore storage and blending piles. Dust generation on the ore haul road can be controlled by sprinkling.

Stabilization of a tailings pile involves grading the tailings area to lessen side slopes, establishing drainage diversion, and covering with a suitable type of material to prevent erosion and wind blowing of the material.

INACTIVE URANIUM MILL TAILINGS SITES

Hearings were held by the Joint Committee on Atomic Energy to obtain information needed to define the problem with respect to inactive uranium mill tailings piles, and to establish procedures within the Federal Government for a remedial action program. Following these hearings in May 1974, the Environmental Protection Agency and the Atomic Energy Commission (now the Energy Research and Development Administration) conducted a Phase I study of 21 inactive tailings pile sites to define the extent of the problem and to recommend possible solutions. The summary of the findings and conditions at the time of Phase I has been submitted to the Joint Committee on Atomic Energy, other Federal agencies, and to the states involved. These findings formed the basis for the initiation of a Phase II effort. (7) This is an engineering assessment to develop cost estimates for a remedial action program to reduce the environmental impact.

Since neither the Environmental Protection Agency nor the Energy Research and Development Administration has the in-house capability to carry out the detailed work needed for a Phase II study, ERDA entered into a contract with an architect-engineering company to perform most of the specific services required. Funds have been made available from the EPA energy fund and then passed through the ERDA to initiate Phase II studies. A portion of these funds will be allocated for research on pile stabilization. The Phase II work is proposed to start at Salt Lake City; the remaining sites will be evaluated within a time frame of approximately two years.

ERDA is the lead Federal agency in these program efforts and will thus have the responsibility to seek the necessary funds from Congress to perform a Phase III study, which will be the implementation of the remedial actions that were determined in Phase II.

NAVAJO NATION STUDY

As a result of various formal and informal requests from both the Navajo Nation and the Indian Health Service, the Environmental Protection Agency and, earlier, the Public Health Service have provided technical assistance and advice to the Nation since about 1968 on matters dealing with mill tailings piles on the Navajo Reservation. During 1974, gamma surveys were conducted at four sites (Monument Valley, Tuba City, Mexican Hat, and Shiprock) on the Navajo Reservation. At the same time, a few air, soil, tailings and gamma logging were used to establish the depth of tailings contamination. Recommendations for remedial action for decontamination were officially provided to the Navajos by the EPA Office of Radiation Programs after preliminary discussion and review of the recommendations by an interagency group at Shiprock, New Mexico, in July 1974. Such recommendations were requested by the Indian Health Service and the Chairman of the Navajo Nation prior to the Environmental Protection Agency/Atomic Energy Commission commitments to the Joint Committee on Atomic Energy to conduct Phase I/II studies at inactive uranium mill sites.

NRC STABILIZATION GUIDELINES

The Nuclear Regulatory Commission and the Agreement States are responsible for the licensing of new uranium mills. As a condition to the licensing of a new mill, pile stabilization will be required before decommissioning the mill.

In 1974, the Atomic Energy Commission issued a new guide in its Regulatory Guide Series. The new guide, Regulatory Guide 3.23, is entitled, "Stabilization of Uranium--Thorium Milling Waste Retention Systems." The guide describes the principal stabilization, maintenance, and long-term control criteria acceptable to the Regulatory staff that should be considered in the construction and use of tailings retention systems at uranium and thorium mills containing radioactive materials. This guide endorses the requirements and criteria included in American National Standards Institute N313-1974, "Stabilization in Uranium--Thorium Milling Waste Retention Systems."

TRACK ETCH BADGE DOSIMETRY STUDIES

Studies of natural radioactivity in the environment have created a requirement for an economical, convenient, noise free, and accurate method of determining radon daughter exposure levels in structures. In order to provide such a dosimetric method, the EPA has funded a contract to develop the measurement technique using the Track Etch principle. As part of a cooperative project with the state of Colorado, the Track Etch Badge is being field tested at selected locations in Grand Junction, Colorado. Results of the Track Etch Badges are being compared with results of the thermoluminescent dosimeter (TLD) air samplers operated at the same locations. Since there is a long history of operation for this measurement technique, it was selected for use in the field study to determine if the new Track Etch Dosimeter should be made available for field use.

RADIOACTIVITY FROM NON-NUCLEAR INDUSTRIAL PROCESSES, EFFLUENTS, RESIDUALS, AND PRODUCTS

Numerous industries process raw materials which occur in strata containing significant quantities of radioactive materials. While buried in the ground, the radioactivity is of little consequence to man because of the shielding effect of the overburden. However, when the raw ores are mixed and processed into products such as fertilizers and building materials, the radioactive components are subject to distribution wherever the product is used. Further, individual workers are subject to direct exposure by close proximity to radioactive materials during ore extraction, separation, and processing.

In the United States there are now approximately 42 million tons of marketable phosphate rock produced annually. About 88 percent of this comes from the southern states of Florida, North Carolina, and Tennessee, while the remainder comes from the western states of Idaho, Montana, Utah, and Wyoming. In 1972, the rock was used for fertilizers (about 24 million tons), elemental phosphorus (about 5.1 million tons), and feed supplement and other uses (about 289 thousand tons). The remainder (about 14.3 million tons) was exported.

The Environmental Protection Agency has a program to assess the radiological impact of industries using materials containing naturally occurring radioactivity. To begin the program, EPA has started with the phosphate industry. The objective is to assess the radiological impact from effluents, wastes, products, and by-products of the phosphate industry and, where necessary, to develop cost-effective controls.

Samples have been obtained from several wet process plants, thermal plants, and mines in Florida, North Carolina, Alabama, and Idaho. EPA has sampled raw ores, marketable ores, phosphoric acid, triple superphosphate (TSP), diammonium phosphate (DAP), monoammonium phosphate (MAP), normal super phosphate and by-products, slag, ferrophos, and gypsum. In addition, investigations have included effluent treatment systems, ambient air concentrations, and reclaimed land concentrations.

In Florida, where large tracts of land have been strip-mined for phosphate rock, the industry is currently involved in extensive land reclamation projects. So far, reclaimed land is used for cattle grazing, municipal structures, and residential buildings. Over the ensuing years, EPA anticipates that much use will be made of this land for habitable structures. Consequently, EPA is investigating the concentrations of uranium, radium, and daughter products to determine if there is any potential hazard to occupants of structures erected on these sites. It is anticipated that if a hazard exists it will be caused by buildup of radon-222 within these structures. At this stage the data is preliminary and further study is needed before the assessment is completed.

Uranium concentrations have been found in copper veins during routine mining operations. By-products of uranium have appeared in residues of copper smelting operations. Uranium and thorium have also been associated with the mining of vanadium, fluorspar, lead, titanium, and the rare earths. The concentrations of the uranium and thorium varies depending on the location of the mine. The impacts and the potential health effects from these mining operations will be considered in the future.

RADIOACTIVITY IN NON-NUCLEAR ENERGY SOURCES

To meet urgent energy demands, many nations are initiating ventures in alternative energy strategies. Some of these energy resources have natural radioactivity associated with them. Radon has been found in geothermal power sources, natural gas, and liquefied petroleum gas. Quantities of uranium have been found in Western coal. With possible increased development of the Western coal because of its low sulfur content, the radioactivity contained in the coal may become a significant source of exposure. This could be as a solid waste problem in the fly ash or as an air pollution problem if the effluent control equipment does not adequately remove all radionuclides.

RADON IN NATURAL GAS

In late 1973, the Environmental Protection Agency published a report entitled, "Assessment of Potential Radiological Health Effects from Radon in Natural Gas." This report summarized the findings of the Environmental Protection Agency concerning the estimation of health effects from the release of radon in dwellings through use of natural gas in unvented cooking ranges or space heaters. In 1974, EPA initiated a similar study to assess the radiological health effects from radon in liquefied petroleum gas (LPG).

EPA concluded that the use of natural gas containing radon-222 for average exposure conditions does not contribute significantly to lung cancer deaths in the United States. For average exposure conditions, the radon from natural gas produced insignificant indoor radon concentrations. No available information was found to evaluate local conditions where individuals may receive exposure from radon daughters much higher than the average. (12)

RADON IN GEOTHERMAL SOURCES

To meet urgent energy demands, many nations are initiating ventures in geothermal technology. The Department of Interior has identified 44 known geothermal resource areas in the United States. (Department of the Interior's Final Environmental Impact Statement for Geothermal Leasing Program--1973). While the needed environmental and health impact data is scarce or non-existent at this time, (1) some concentrations of radon have been found with particular geothermal energy sources.

The Office of Radiation Program Las Vegas Facility (ORP-LVF) of the Environmental Protection Agency is now conducting a sampling program in thermal springs, pools, lakes, and rivers (geothermal sources). Radium in water, radon in water and steam, and radium and thorium in sediments are all being measured. This work includes gathering data on background information on the geology and chemistry of geothermal areas.

URANIUM AND DAUGHTERS IN WESTERN COAL

The concentration of radium in coal varies with the ash content and other factors. A coal-fired power plant can discharge amounts of long-lived biologically significant radioactivity. In a well-run plant, less than 1 percent of the total radioactivity contained in the coal is discharged into the atmosphere in the form of fly ash. The remaining ash is handled in a wide variety of ways, some of which may involve opportunities for population exposures (16).

Some types of rocks are far more favorable hosts for uranium than others. Thus, the physical properties of peat, lignite, and sub-bituminous coal are rather different in their capacities for concentrating uranium in those important fuel materials, (9) and are found with rather different concentrations of this radioactive contaminant.

The United States Geological Survey has made extensive investigations of the occurrence and distribution of uranium in coal and related carbonaceous materials throughout large areas in the western United States. By the use of portable geiger and scintillation counters, hundreds of outcrops of coal have been tested for radioactivity, and samples have been collected for chemical and spectrographic analyses. The uranium content of the coal in these deposits ranged from 0.005 to 0.02 percent. Much of the uranium was found to be disseminated in the carbonaceous material.

Uranium has also been found in the groundwaters adjacent to the western coal. In general, it was found that the greater the alkalinity of the groundwaters, the more uranium the waters contain.

RADIUM AND DRINKING WATER/STANDARDS

In general, groundwaters contain more natural radioactivity than surface waters (3). Water treatment procedures instituted for non-radiological reasons may also remove some radionuclides. A dosage can be received from ingestion of radon rich water, or by inhalation of the radon which readily emanates from open water or water undergoing aeration. Household use of water entailing heating, agitation, and aeration could constitute a potential hazard from airborne radon and its daughter products.

Unlike limits for other chemical constituents in drinking water, radiological approval limits cannot be based on an assumed harmless level of radiation dose. Rather, controls for both individual and population exposures should be based on the prudent assumption that there is no threshold dose for ionizing radiation and that any health effects would be proportional to the dose delivered by the ingested activity.

EPA has a current program to evaluate cost-effective methods for removing radium from drinking water. This work includes both cost and engineering analyses. Involved in the same program are two state agencies, Iowa Department of Environmental Quality, and the Illinois Environmental Protection Agency.

The contract with the Iowa Department of Environmental Quality provides for studies at up to 10 drinking water supplies. Sample collection and analysis are complete at all nine systems. Cost data have been collected and are being analyzed. The contractor has submitted preliminary data on all supplies. From these data, preliminary decontamination factors for each process have been calculated. The final report from this contractor is due in October 1975. A similar contract with the Illinois Environmental Protection Agency provides for studies at five to eight drinking water supplies. Radium analysis is being performed at the Argonne National Laboratory.

Under the Safe Drinking Water Act of 1974, EPA has the authority to set standards for radioactivity levels in drinking water. The Office of Radiation Programs has been involved with developing that portion of the Drinking Water Standards that applies to radioactivity. A national interim primary drinking water regulation on proposed maximum contaminant levels for radioactivity is under development. EPA believes that the establishment of such levels as proposed will protect health to the extent feasible and aid achievement of national goals of safe drinking water.*

RADIOACTIVITY IN CONSTRUCTION MATERIALS

Construction materials may account for a significant exposure to the U.S. population from naturally occurring radioactivity. It has long been known that some building materials, such as granite, are naturally more radioactive than others. (3) Recently, particular emphasis has been given to the use of uranium mill tailings as construction fill. Concentrations of radioactivity have also been associated with the use of the waste product gypsum for plaster board. The removal of these materials from the ground for subsequent use in dwellings constitutes an example of natural radioactivity increased by man. Other building materials being evaluated for possible radioactivity included uranium ore leach residues in Sweden (Bergstrom and Wahlbug, 1968), ceramic bond fly ash, and foamed blast furnace slag (Roka, 1966).

Efforts are now underway (a) to increase our understanding of the degree of exposure associated with these materials, (b) to evaluate available methods to identify high exposures from construction materials, and (c) to control their application. Inter-governmental coordination is required of all agencies involved in the selection and quality of construction materials used in the United States.

In making phosphoric acid by the wet process, a large quantity of gypsum (calcium sulfate) is produced. To date, there has been a very limited market for this gypsum. Consequently, each phosphoric acid plant has a large store of gypsum typically between 50 to 300 acres about 50 to 100 feet high. In Europe, and particularly in Japan, by-product gypsum is being used to make wallboard. Preliminary data indicates that the by-product gypsum contains 20 to 43 pCi/gram of radium-226. The Bureau of Mines has a small pilot project designed to determine if the by-product gypsum could be successfully manufactured into high quality wallboard. EPA has obtained samples of the processed gypsum from the Bureau to determine the concentrations of radioactive materials in the final product. From this data, EPA is modelling structures to determine the dose to residents. The purpose is to evaluate this use as soon as possible, because increasing mining costs for regular gypsum makes it appear that recovery of the by-product gypsum for wallboard may be economically desirable in the near future. Other potential manufacturing uses of this gypsum in the production of ammonium sulfate fertilizer, sulfuric acid, and Portland cement are being studied throughout the world.

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*EPA published the interim primary drinking water regulation in the Federal Register dated August 14, 1975.

In the production of elemental phosphorus, a major by-product is slag. Preliminary data indicates that slag contains about 50 to 60 pCi/gram of radium-226. Uranium content would be expected to be similar in values. It appears that the slag is now being widely used for highway material, concrete, aggregate, and crushed stone. EPA is continuing to investigate slag concentrations in order to draw conclusions regarding the acceptability of slag for various uses.

Surveys conducted to evaluate the hazards associated with the use of uranium mill tailings for construction purposes have not been fully reported in the literature. Detailed reports have been issued to individual states where tailings material were used for construction purposes. These state reports include the results of a mobile gamma-scanning survey and the results of portable instrument radiation surveys completed inside and outside of selected dwellings. In 1974 Duncan and Eadie presented data on the evaluation of the indoor working level values and also on some indoor gamma radiation survey results for structures built immediately adjacent to a uranium mill tailings pile located in Salt Lake City, Utah.

OUTLOOK FOR THE FUTURE

As man seeks to improve his standard of living and demands greater use of available natural resources, he is no longer shielded from natural radioactivity contained in the earth. The result is increased potential exposure to population groups. As the use of these natural resources increases, there arises a need to consider the risks to the population versus the benefits derived from using such resources. There are both immediate and long term needs to research, evaluate, and provide control measures for natural radiation. The following areas typify needed research efforts:

- Develop radiation control and regulations for uranium mill sites and uranium tailings and wastes burial sites.

- Identify cost/effective techniques for pile stabilization.

- Determine needs for additional controls for the phosphate industry and formulate allowable levels of discharge from phosphate fertilizer plants.

- Examine construction materials and radioactivity and determine the need for new building controls.

- Assess exposure due to radon and daughters from geothermal sources.

- Evaluate environmental impact from radioactivity in coal-fired power plants and coal gasification.

- Continue assessment of radon in natural gas, LNG, and LPG.

- Develop accurate, cost/effective, and reliable instrumentation to measure natural radioactivity and establish an effective quality assurance program.

- Finalize standards for drinking water and evaluate radium removal techniques.

- Evaluate radioactivity associated with vanadium, fluorspar, copper, lead, titanium, and rare earth mining operations.

REFERENCES

1. Axtmann, Robert. "Environmental Impact of Geothermal Power Plant," *Science*, March 7, 1975.

2. Congress of the United States, Hearings Before the Joint Committee on Atomic Energy, February 5 and 6, 1974.

3. Gesell, Thomas and Prichard, Howard. "The Technologically Enhanced Natural Radiation Environment," *Health Physics*, April 1975.

4. Liverman, James L. Statement Before the Joint Committee on Atomic Energy, February 27, 1975.

5. National Academy of Sciences. *The Effects on Populations of Exposure to Low Levels of Ionizing Radiation*, Washington, D.C., 1972.

6. Oakley, Donald. *Natural Radiation Exposure in the United States.* Washington, D.C.: U.S. Environmental Protection Agency, 1972.

7. Summary Report Phase I Study of Inactive Uranium Mill Sites and Tailings Piles, October, 1974.

8. U.S. Department of Health, Education and Welfare. Sixth Annual National Conference on Radiation Control. April 28 - May 2, 1974.

9. U.S. Department of the Interior. *Uranium in Coal in the Western United States*, Geological Survey, Washington, D.C., 1959.

10. U.S. Environmental Protection Agency. *Environmental Radiation Dose Commitment: An Application to the Nuclear Power Industry*. EPA-520/4-73-002, Washington, D.C., 1974.

11. U.S. Environmental Protection Agency. *Assessment of Potential Radiological Health Effects from Radon in Liquefied Petroleum Gas*, Washington, D.C., (Draft), 1975.

12. U.S. Environmental Protection Agency. *Assessment of Potential Radiological Health Effects from Radon in Natural Gas*. EPA-520/1-73-004, Washington, D.C., 1973.

13. U.S. Environmental Protection Agency. *Environmental Analysis of the Uranium Fuel Cycle*, Part I - Fuel Supply, EPA-520/9-73-003-B, Washington, D.C., 1973.

14. U.S. Environmental Protection Agency. Radiation Data and Reports. Volume 15, Number 1, Washington, D.C., January 1974.

15. U.S. Environmental Protection Agency. National Radiation Protection Program Strategy and Plan, 1972.

16. Martin, James E., "A Comparative Population Radiation Dose Commitment of Nuclear and Fossil Fuel Electric Power Cycles," Proceedings of the 8th Annual Topical Symposium on Population Dose, Health Physics Society (Knoxville, Tennessee) 24 October 1974.

CHAPTER 4
MEDICAL AND OCCUPATIONAL

INTRODUCTION

The responsibility for controlling medical and occupational exposure to radiation generating equipment and radioactive materials is divided between the Federal and the State governments. Within the Federal government, the Environmental Protection Agency (EPA), the Department of Health, Education, and Welfare (DHEW), the Department of Labor (DOL), and the Nuclear Regulatory Commission (NRC) are responsible for protecting the public against the deleterious effects of ionizing radiation.

The responsibility establishing general Federal radiation guidance applicable to all Federal agencies now resides in the Environmental Protection Agency. This authority, which was previously vested in the Federal Radiation Council by the Atomic Energy Act (PL 83-274h), was transferred to the EPA by Reorganization Plan Number 3 of 1970. As a consequence, the EPA administrator is now charged by law 42 USC 2021h to advise the President on radiation matters directly or indirectly affecting health, including guidance for all Federal agencies in formulating radiation standards. Federal agencies and the fifty State governments have complementary responsibilities to establish regulations to control the use of radiation.

MEDICAL

THE MEDICAL RADIATION PROBLEM

Ionizing radiation represents a valuable diagnostic and therapeutic tool in medicine, and its use has expanded substantially since its introduction for such purposes about the turn of the century. Indeed, the exposure of the general public to X-ray sources in medicine and dentistry is the largest manmade contributor to radiation exposure of the U.S. population. Medical and dental X-ray equipment currently account for over 90 percent of all manmade human exposures to ionizing radiation. In 1970 alone, 129 million people (or 63 percent of the population), received 210 million medical diagnostic X-ray examinations. In the process, an estimated 3 million pregnant women were subjected to X-ray procedures. Other population segments - such as the elderly - were also subjected to a high number of examinations per capita.

The diagnostic and therapeutic uses of radiopharmaceuticals are another source of ionizing radiation in medical practice. In 1970, 6-8 million individuals were administered such radiopharmaceuticals. Other sources of radiation exposure derive from the use of microwaves, ultrasonics, lasers, and diathermy equipment for diagnostic and therapeutic purposes.

The attendant benefits from the use of radiation for medical and dental diagnosis and therapy are well recognized and are not at issue. However, the risks associated with undergoing efficacious radiation procedures needed for proper medical care must always be offset by the benefits derived.

X-ray radiation protection became an important concern in the first decades of this century when it was found that radiologists and their assistants had a higher mortality rate, a higher rate of cancer induction, and a shorter life span than other physicians. It was the demonstrated deleterious effects of large acute exposures to radiologists and their assistants which provide the stimulus for the first radiation protection guides. The effects of exposure on the equipment operators were, therefore, of more concern than the effects of excessive and unnecessary exposure to patients, as little concern was given to protecting the patient.

While the safety of the personnel performing the X-ray procedures is important, EPA is concerned also with potential unnecessary or excessive exposure to the patient, particularly as it relates to both the increased number of films per procedure and the higher exposure per film noted in recent years. A Nationwide Evaluation of X-ray Trends (NEXT), a program conducted jointly by the Food and Drug Administration/Bureau of Radiological Health (FDA/BRH) and the States, found many kinds of unnecessary exposures. Of special concern are those X-ray procedures which are particularly dose intensive, include in the primary beam certain body organs such as the genitals, or suggest less than optimal exam techniques.

In addition to the patient and medical personnel exposed while treating and diagnosing disease, the general population may be exposed to radioisotopes which have been discharged to the environment. This may take place through sewer systems and associated waste treatment facilities. A cooperative BRH/EPA study on sewage radioisotope contamination in the Cincinnati area was completed and findings reported in 1974 (4). This exposure results from the current lack of regulations controlling the handling, storage, or disposal of the excreta of patients who have been administered radiopharmaceuticals. To minimize such contamination of the environment, special precautions are particularly needed in facilities using large amounts of radioactive materials.

ISSUES OF MEDICAL RADIATION USE

The United Nations Scientific Committee on the Effects of Atomic Radiation in 1972 (1) stated: "The awareness of the radiological staff of the importance of the protection of the patient is probably the greatest factor in the control of population exposure." Moreover, a significant portion of present consumer-patient exposures can be avoided, without a decrease in benefits, by improvements in training, equipment, techniques, and procedures in administering radiation to patients, and particularly by the application of X-rays in diagnostic procedures.

A report of the National Academy of Sciences - National Research Council Advisory Committee on the Biological Effects of Ionizing Radiation (BEIR Committee) (2) dealt with the scientific basis for the establishment of radiation protection standards and reviewed and reevaluated existing scientific knowledge concerning radiation exposure of human populations. This report states that "the aim is not only to reduce the radiation exposure to the individuals, but also to have procedures carried out with maximum efficiency so that there can be a continuing increase in medical benefits accompanied by a minimum radiation exposure." In this regard, the Committee concluded "...that it appears reasonable that as much as 50 percent reduction in the genetically significant dose from medical radiology might be possible through improved technical and educational methods."

Therefore, from a radiation protection viewpoint, the major issues in medical radiation deal with strategies to achieve three main objectives.

The first objectives is to ensure that all equipment in use is of the best quality and complies with applicable performance standards. Inspection procedures and an effective maintenance program must be instituted with follow-through and follow-up to ensure that the standards are continuously met. In addition, even the best quality equipment should be used only in conjunction with shielding equipment to protect non-examinated parts of the patient's body and the whole of the operator's body.

The second objective is to eliminate clinically unnecessary exams. Although physicians are not in complete accord as to which specific exams are unnecessary, it is generally thought that those which could be eliminated are exams that provide few benefits compared to their associated risks. These include: routine radiographic screening type exams, used in annual physical exams; pre- and post-employment physicals, including chest screening or lower back exams; public health screening; and pelvic screening exams to estimate the likelihood of difficult childbirth.

The third objective is to utilize optimal techniques to assure that the radiation dose for exposure is as low as readily achievable while maintaining desirable image quality. This requires use of appropriate technique variables such as speed of the film and screens, processing time, KVp, and mAs. Use of less than optimal technique variables may cause a ten fold increase in patient exposure as compared to the exposure incurred using optimal technique variables in a similar exam. Also, the training of equipment operators is important to good technique. Training standards, operator qualification standards, and licensing requirements need consideration in achieving this objective.

PROGRESS IN MEDICAL RADIATION PROTECTION

During 1974, several significant events occurred in the field of medical radiation protection regulation and control. They represent an encouraging trend for human and environmental protection. At the Federal level, programs of both the Environmental Protection Agency and the Department of Health, Education, and Welfare were directed toward reduction of population exposure from medical radiation.

The Environmental Protection Agency took steps to include medical radiation within Federal radiation protection guides. An Interagency Working Group was formed to assist EPA in initiating a Federal effort to reduce unnecessary radiation exposures from the use of X-rays in the practice of medicine. This Interagency Working Group was established in August 1974 and will develop as a cooperative Federal effort the Federal guidance for medical use of radiation in Federal health care programs.

In June 1974 hearings before the Senate Committee on Commerce found that air shipments of radionuclides are a source of needless exposure to passengers, up to rates in the vicinity of 25 mrem/hour. The NRC furnished data on the effectiveness of increased shielding, and EPA studies indicated that more adequate shielding is technically and economically achievable. Consequently, EPA has recommended to those Federal agencies*

*The Department of Transportation/Federal Aviation Administration, the Nuclear Regulatory Commission, and the Food and Drug Administration/Bureau of Radiological Health.

charged with the regulation of the transportation of radioactive materials that the dose rate to any passenger not exceed 0.5 mrem/hour.

A consequence of increased use of medical radioisotopes is increased discharges of these materials to the environment principally via municipal sewage facilities. In 1974, EPA initiated studies to determine the nature and extent of this problem by a contract with the University of Texas Health Science Center at Houston School of Public Health, Houston, Texas.

The FDA's Bureau of Radiological Health continued programs designed to control radiation exposure from electronic products under authority contained in the Radiation Control for Health and Safety Act of 1968 as follows:

- Performance standards for diagnostic medical and dental X-ray equipment were promulgated with an effective date of August 1, 1974.
- An agreement was reached with the U.S. Customs Office for an interagency program to assure that all imported electronic products comply with applicable performance standards issued under the Radiation Control for Health and Safety Act.
- Performance standards for cabinet X-ray systems become effective April 10, 1975 except carry-on baggage systems which were effective April 25, 1974.
- A performance standard was promulgated to prevent human access to radiation from lasers.
- An amendment was made to the microwave standard.
- A draft performance standard was proposed for ultrasound equipment.
- An amendment was proposed to the Radiation Control for Health and Safety Act to add sun lamps and certain medical ultraviolet lamps.

The U.S. Senate passed Senate S. 2994 Title 7 as part of the Comprehensive Health Planning Act of 1974 requiring DHEW to establish standards to license radiologic technologists. This section was removed when the bill went to the Joint Conference. Since the Senate has passed the bill, it is reasonable to anticipate eventual enactment of the legislation and its implementation by Federal programs.

At the State level, the National Conference of Radiation Control Program Directors (3) adopted a resolution in May 1974 urging the Congress and State legislatures to adopt "such legislation as is presently before them to assure the continuation or implementation of programs for licensure of operators of medical diagnostic X-ray equipment." The resolution urged the Congress and the Food and Drug Administration "to adopt a policy supporting such legislation" and urged further that the "Food and Drug Administration actively assist states in drafting state legislation and organizing an effective implementation of present and future operators licensing legislation."

Beginning with New York in 1964, a number of states have initiated programs requiring licensure of radiologic technologists. Three states - California, New Jersey, and New York - and Puerto Rico have mandatory programs, while three other states - Hawaii, Kentucky, and Vermont are in the process of implementing licensure statues. Some thirteen state legislatures are presently considering licensure proposals. Of note, the State of California's licensure law requires anyone who takes or supervises the taking of X-rays, including licensed practitioners, to attest to minimum qualifications.

It is anticipated that the licensure of technologists would result in a reduction of the amount of radiation exposure caused by the use of sub-optimal X-ray techniques. The premise is that a technologist who has demonstrated technical competence would commit fewer errors in optimizing the exam technique factors.

An entirely different method to reduce patient exposure has been adopted by the State of Illinois. Effective January 1, 1975, the Illinois Division of Radiological Health has established regulations which limit the amount of radiation exposure for selected routine radiographs.

It is expected that the regulatory activities of 1974 will cause a decrease in the exposure per patient. However, the collective exposure of the general population is expected to increase in the future because of population growth and the extension of medical and dental care to a larger proportion of the population through Medicare and other health insurance programs. Increased use of diagnostic radiological procedures in medical practice suggests the need to limit individual exposures to as low a level as reasonably achievable.

OCCUPATIONAL

THE ISSUES OF OCCUPATIONAL EXPOSURE

Employees in industries involving radiation are exposed to radiation by handling radioactive materials or entering areas which have radiation levels or are contaminated by radioactive material. Current guidance on occupational exposure is contained in the former Federal Radiation Council's Memorandum for the President, "Radiation Protection Guidance for Federal Agencies," approved and signed by the President on May 13, 1960. These guides are used by all Federal agencies in their activities. During the fifteen years since this guidance was established, there has been an increase in the number of persons occupationally exposed (800,000 in 1970); changes have been made in methods of calculating doses and their effects; new national requirements have been promulgated on increasing uses of sources, new occupations have been created and have exposed sensitive population groups; and new and relevant scientific information on risks of low-levels of radiation and exposure patterns by occupation has been acquired.

PROGRESS IN OCCUPATIONAL RADIATION PROTECTION

Because of the increased number of persons being exposed to ionizing radiation and increased information on the risks of radiation exposure, the Environmental Protection Agency has undertaken a program to reconsider all factors relevant to updated Federal guides for occupational exposure. As part of the program, EPA established an Interagency Committee on Occupational Exposures to Ionizing Radiation in September 1974 to advise EPA in developing guides sufficient to protect the radiation worker from undue risk. A program for routinely compiling national statistics on annual occupational exposure is under study. A contract to develop a program to compile statistical data on annual occupational exposure to ionizing radiation within the United States is expected to be awarded in 1975.

THE OSHA ROLE IN RADIATION HEALTH PROTECTION

With the growing increase in the use of industrial radiation techniques has come a serious concern for workers who, in the course of normal work activity, may come near potentially-dangerous sources of ionizing or non-ionizing radiation. The Occupational Safety and Health Act of

1970 demonstrates a concern with such techniques. This legislation created the Occupational Safety and Health Administration of the Department of Labor, with the power to promulgate safety standards and to make on-site inspections. Congress gave enforcement authority to the Occupational Safety and Health Administration (OSHA). The administration includes a system of fines and citations costly enough to ensure compliance with the law.

The law provides OSHA with jurisdiction over all employers engaged in interstate commerce. Recent judicial interpretation of the constitution's interstate commerce clause assures that virtually all employers are legally bound by the act. There is, however, an exception which applies to radiation. Section 4(b)(1) excludes employees who are under the authority of Federal and State agencies acting under Section 274 of the Atomic Energy Act of 1954. However, even these licensees are subject to OSHA inspection and citation if they have X-ray equipment or accelerators. Statistically, then, about 57 percent of all people who are exposed to radiation in their work environment are directly under OSHA's aegis.

Whether or not a work facility will be inspected depends essentially on one or more of three factors. First, OSHA gives priority to an investigation involving a catastrophe or fatality. Second, under an arrangement which guarantees the anonymity of the complaint, a worker may complain to the Secretary of Labor if he feels his workplace is not safe or healthful. Third, inspections are made on a random selection, unannounced basis. The decision to make a random inspection is made at the OSHA area level (in effect, at the local level).

Thus far, the number of actual radiation inspections has been comparatively small compared to the total number of inspections made by OSHA's Compliance Safety and Health Officers. However, we can anticipate that - as part of the random selection and inspection program - radiation inspections will become a more significant part of the OSHA function.

OSHA closely follows the standards developed by the former AEC for occupational exposure. New standards based on more recent research are being considered and studied, but have not yet been promulgated.

REFERENCES

1. Ionizing Radiation Levels: Levels and Effects, Volume I and II, United Nations Scientific Committee on Effects of Atomic Radiations, New York, 1972.

2. National Academy of Sciences/National Research Council, The Effects on Population of Exposures to Low Level of Ionizing Radiation, Report of the Advisory Committee on the Biological Effects of Ionizing Radiation, (BEIR Report) NAS/NRC report, November 1972.

3. U.S. Department of Health, Education and Welfare, Sixth Annual National Conference on Radiation Control, April 20 - May 2, 1974.

4. Sodd, V. J., Felton, R. J., and Saenger, E. L., 1974 An Investigation of the Disposal of Radiopharmaceuticals in the Cincinnati Sewer System. First World Congress of Nuclear Medicine, Tokyo, Japan, October 1974.

CHAPTER 5
NONIONIZING RADIATION

INTRODUCTION

Nonionizing radiation is defined as radiation occurring in that portion of the electromagnetic spectrum from 0 hertz (Hz) through 10^{16} Hz; these are the frequency ranges used in such commonplace functions as household current (60 Hz in the U.S.), high voltage electrical power lines, radio communications, TV broadcasts, microwaves (including radar, microwave ovens, point-to-point microwave transmission towers, satellite communications and medical diathermy devices), and infrared, visible, and ultraviolet light (including sunlight, lasers, sunlamps, and high intensity lamps). Basically, nonionizing radiation is concerned with that portion of the electromagnetic spectrum where energies are below the atomic ionization potential for molecules of biological importance; thus, the energy transfer is primarily through atomic vibrations and rotations. Those nonionizing devices primarily associated with medical and industrial areas have been discussed in Chapter 4.

Nonionizing radiation has become a national concern because of the rapid increase in its use for industrial, communication, and consumer applications, and because of its potential harm to public health. It is a major concern especially with low level exposure, because (a) the environmental levels are unknown, (b) the number of sources is rapidly increasing, and (c) the controversy over low level radiation effects is heightened by the difference in human exposure standards, especially between the United States (7, 8) and the Soviet Union (1).

In order to establish a more uniform approach to the discussion of mechanisms underlying biological effects, microwave intensities are divided into three approximate ranges: (a) the range above 10 mW/cm^2 (high level) in which distinct thermal effects predominate; (b) the range below 1 mW/cm^2 (low level) in which thermal effects are improbable; and (c) an intermediate range in which weak but noticeable thermal effects occur, as well as direct field effects and other effects of a microscopic or macroscopic nature, the details of which have not yet been clarified (47).

The limits of these ranges have not yet been determined. They may differ for various species and may also depend on a variety of parameters, such as modulation and frequency.

The effects from exposure to high levels of nonionizing radiation (such as those produced by some radar and satellite communication facilities or other high intensity sources) have been referred to frequently as "thermal" effects. Low level effects have been referred to as "nonthermal" effects. The term "nonthermal" effects is imprecise and will be avoided as much as possible.

A variety of health effects have been observed from exposure to nonionizing radiation. The thermal effects result from temperature increases in tissue caused by the radiation (electromagnetic energy) absorbed and converted into heat energy. Nonionizing radiation has beneficial applications in diathermy, microwave cooking, and industrial heating processes, but, improperly used, there can be harmful side effects which include heat stress (e.g., heat prostration), burns, cataracts of the eyes, and testicular degeneration. (32)

Documentation (14) exists concerning microwave hearing i.e., the perception of audible noises produced by interaction of the body with high power sources such as radar. The microwave hearing mechanism is only partially understood, and no adverse biological effects are yet determined. At levels of exposure in the range of 0.01 milliwatts per square centimeter there is some evidence of nervous system and behavioral effects (1, 23). These effects may be due to localized heating or other molecular disorderings. This evidence has come from certain European countries, some (1, 23) of which have adopted standards for microwave exposure which set occupational levels at one-thousandth of the current standard used in the United States. The nervous system and behavioral effects have not yet been verified in this country, although several research programs have been initiated, both within the Environmental Protection Agency (EPA) and outside, to determine the existence and significance of such effects.

Besides the categories of biological effects which are related to the various power density levels, the other major category of effects from nonionizing radiation is electrical interference. This includes critical communications systems, electronic control systems, life support systems (such as heart pacemakers), or inadvertent triggering of detonations (blasting). Some anti-lock or anti-skid brakes, as well as some fuel-injection (electronic) systems have been known to fail because of electrical interference.

Whether the environmental nonionizing radiation problem is limited to the relatively high levels of exposure in the vicinity of individual high power sources, or whether it is related to the superposition or overlapping of radiation from many sources, it appears that large populations are exposed to significant ambient levels of nonionizing radiation.

The EPA radiation program is providing the first information available on the scope of ambient levels of nonionizing radiation and on the magnitude of potential effects on the exposed populations. This program addresses (27) the need for information and action on (a) the adverse thermal effects on biological systems that occur at levels greater than 10 milliwatts per square centimeter power density for radio frequency and microwave radiation, (b) the adverse effects on biological systems that have been reported to occur at level orders of magnitude below the above power density, and (c) the environmental levels of nonionizing radiation that can significantly interfere with the operation of critical electrical systems.

It is important to understand the difference between effects from sources which are pulsed (such as radar) and effects from continuous wave (CW) radiation (such as radio, TV, and microwave ovens). In the CW radiation category the effects of various modulations must also be addressed. Areas of interest for electromagnetic-biological effects are categorized in Table 5-1 (30).

In the nonionizing frequency range of radiation from light there are potential problems such as eye damage and skin burns. This is particularly true of the intense light from laser systems, where a potential, however, small, exists for irradiation of the general population. Lasers are not generally used in applications which affect the environment, but are usually restricted in accessability and confined in use to limited areas such as scientific, industrial or military applications. Potential hazards exist primarily because of unawareness or carelessness, with the most significant possibilities for hazardous exposure occurring in educational institutions, medical facilities, and in surveying and ranging applications.

There is a growing concern (11) with possible health and environmental effects from extremely high voltage power transmission (greater than 700 kilovolts) because, with the increased demand for electrical generation capacity in the U.S., transmission on 765 kV lines is currently being planned, with future development of 1.2 million volt transmission lines probable. The effects from these high voltages at 60 Hz are those due to (a) electromagnetically and electrostatically induced voltages and currents, (b) electric discharge, and (c) ozone production. Good data needs to be made generally available on the relevant parameters of line height, phase configuration, line voltage, etc. so that reported effects can be evaluated.

Table 5-1 Electromagnetic Bioeffects: Areas of Investigation *

- Genetic/Hereditary/Developmental: chromosomal, mitotic, reproduction/fertility, embryology, and pre- and postnatal development, etc.,
- Nervous System: CNS, sensory, neurochemical-neuroendocrine, and single cell - membrane phenomena,
- Behavioral/Psychological
- Gross Physical Condition/General Health
- Epidemiology (pro- and retrospective)
- Clinical Examinations
- Mechanisms of EM Interaction (with molecules, tissues, body systems, etc.): micro- and macro-
- Other Areas
  A. Ocular
  B. Cardiovascular
  C. Metabolism/endocrinology/biochemical
  D. Thermal/thermoregulatory/lethality
  E. Cytological/historical, morphological
  F. Other Effects: blood GI, respiratory, motor, physical, endurance, stress, biological clocks/rhythms, disease, etc...
- Instrumentation/Techniques/Calibration: bioresearch (EM measurement, special biomedical instrumentation, exposure and calibration facilities), and field measurements (equipment, methodology, etc.)
- Absorption/Dose: analytical/mathematic/theoretical, and experimental (animal, phantom, model)
- Environmental and Safety Studies: environmental surveys, population studies, hazard assessment/safety standards
- Special Features, such as: multiple frequencies, RF with other stressors and environmental factors (e.g., drugs, ionizing radiation, disease, etc.), RF heating vs. other heat sources, chronic vs. short term effects studies, compare difference due to sex, age, and other biological factors, literature studies, and therapy.

*Office of Telecommunications Policy, Ref. 30.

With only minimal health and environmental information available on the direct effects of high intensity 60 Hz field (and this only for animal systems), there is a need to collate what is known before designing an extensive research program. Information is needed on electrical shock from voltages and currents induced in objects in the vicinity of the line. We need to know which effects are considered painful, annoying, or just distasteful.

GROWTH IN NONIONIZING RADIATION

Since 1945, when environmental nonionizing radiation levels were very low, the potential threat to persons and equipment from nonionizing sources has risen dramatically. Radiofrequency and microwave sources alone are estimated to be increasing at 15 percent annually (27). The applications with the highest growth rate include commercial broadcast, microwave ovens (1,200,000 estimated in service at the end of 1974, a 600,000 increase over 1973; 1975 increase estimated at 700,000 to 800,000) (5), landmobile communications (459,000 in 1972), small boats and private and commercial plane electronic systems, radars (military and private) and microwave diathermy.

Until recently the growth of radio and TV stations in the United States has been phenomenal, as is seen in Figure 5-1 (21). As of February 1975, there are 7,928 radio stations (4,436 AM, 2,657 FM commercial, and 735 FM educational).* In addition 6,000,000 transmitting devices had been authorized by the FCC (27) exclusive of Federal Government systems with over 120,000 assigned frequencies (28). It is evident that there are numerous artificial sources of nonionizing radiation influencing the human environment in the United States.

Besides the growth in source numbers and types, the output power density has steadily increased until there are now 86 sites capable of producing a power density of 10 milliwatts per square centimeter at a distance of approximately one mile from the source, while 2,368 sources are capable of producing a power density of 10 microwatts per square centimeter (0.01 mW/cm^2) at the same distance. (35) These two power densities represent the probable extremes of the range of acceptable power densities for environmental standards. Notable high powered sources are satellite communications facilities, airport radar, broadcast TV (UHF), industrial processing applications, and military electronic applications.

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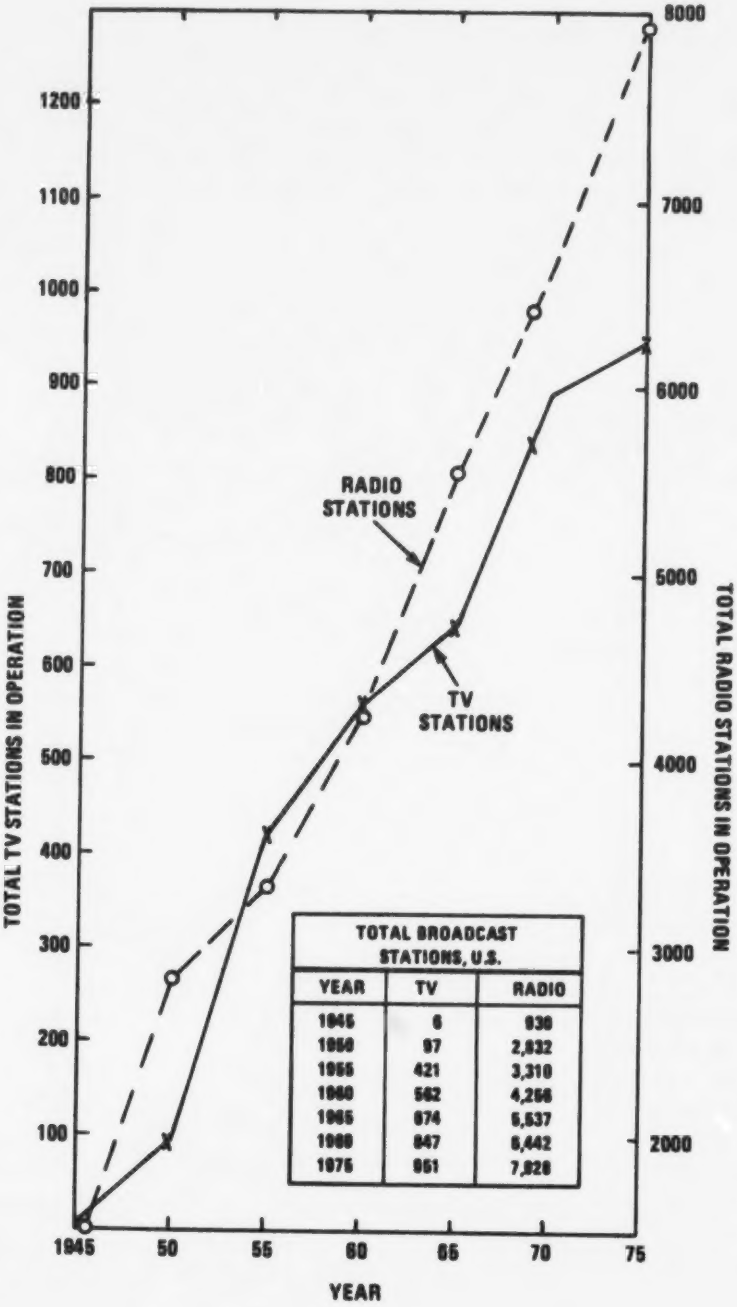
*FCC licensing information office, telephone conversation.



TOTAL BROADCAST STATIONS, U.S.

YEAR	TV	RADIO
1945	6	930
1950	97	2,832
1955	421	3,310
1960	562	4,266
1965	674	5,537
1969	847	6,442
1975	951	7,928

Figure 5-1 Increase in Radio and TV Broadcast Stations in the United States (21)

What is the hazardous level of radiation? Two very different points of view as to hazardous levels are presented in Figure 5-2 (40).

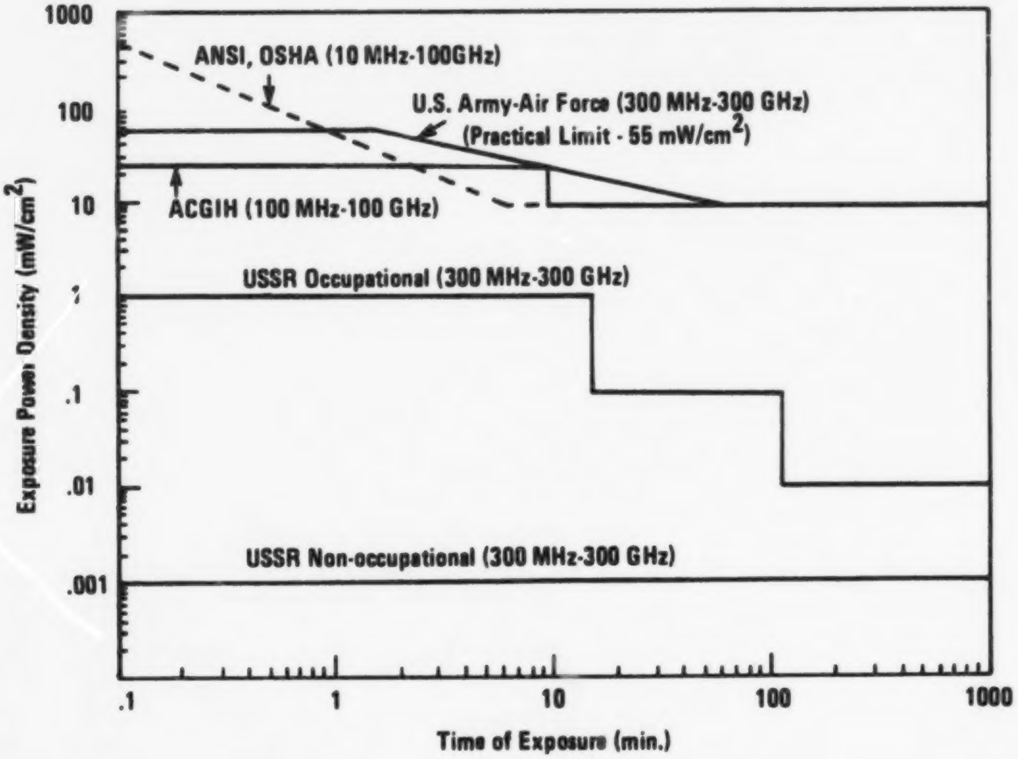


Figure 5-2 Some Selected Microwave Exposure Standards (40)

U.S. standards, e.g., the OSHA standard (7, 8), the American National Standards Institute (ANSI) consensus standard (2), the U.S. Army and U.S. Air Force Standards (42), and the standard used by the American Conference of Governmental Industrial Hygienists (ACGIH) (41), permit continuous exposure to power densities of 10 mW/cm^2 for a period of one hour or more. The difference between the exposures permitted under U.S. and Russian standards is 3 to 4 orders of magnitude (1,000 to 10,000 times). The U.S. standards for nonionizing electromagnetic radiation are based on the premise that biological effects are due to the heat generated when the radiation is absorbed; the Russian standards assume that biological effects occur at much lower power densities and are not due to heating alone (1). Poland has standards (22) that are less restrictive than those of the USSR, but more so than those of the U.S., while Czechoslovakia has standards (20) which fall in between the Polish and Russian standards.

The potential magnitude of the nonionizing radiation problem in our environment is illustrated by Figure 5-3 (35). Figure 5-3a shows the total number of sources within the U.S. which are capable of producing an exposure power density of 10 mW/cm^2 (U.S. Standard) as a function of distance from the source. Reducing the density levels to the levels of the Russian Standard, Figure 5-3b, more than doubles the number of stations which exceed the U.S. standard and increases the perceived dimensions of the problem many fold.

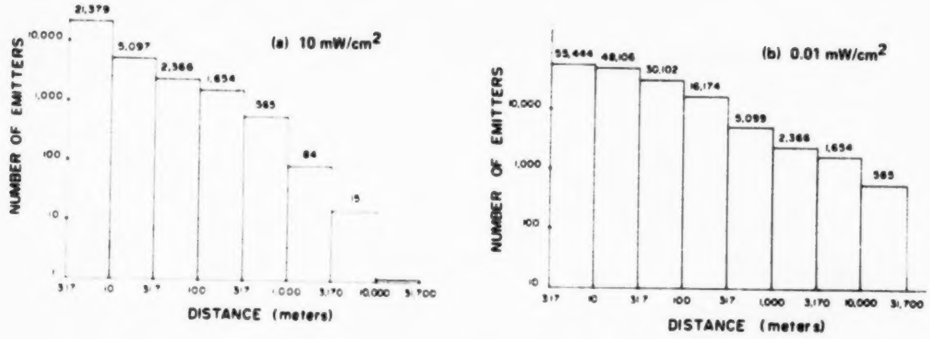


Figure 5-3 Cumulative Distribution of Emitters in the United States Capable of Producing a Power Density Equal to or Greater than (a) 10 mW/cm^2 and (b) 0.01 mW/cm^2, as a Function of Distance. (35)

NONIONIZING RADIATION CONCERNS

Concern over the level and effects of nonionizing radiation has not yet caused any one agency to consider nonionizing radiation as a priority issue across the board. At present the responsibilities for nonionizing radiation research and control are diffused among several agencies. The Department of Health, Education and Welfare (DHEW) is responsible for equipment performance standards, the Department of Labor (DOL) for occupational health and safety, the Environmental Protection Agency for environmental aspects, and user agencies for control over their activities. The Office of Telecommunications (OTP) is attempting to coordinate research, but acts only in an advisory capacity.

The environmental and health risks from nonionizing radiation need to be resolved at all frequencies, both for the biological effects and interference with electronic equipment. In the power density range of below 10 mW/cm^2, it is necessary (a) to determine guidelines for the exposure of the general population where neither the mobility nor the environment of the exposed group is under the control of the operators of the source, and where some segments of the population may be more sensitive to heat stress than those exposed occupationally; and (b) to determine and verify by measurement the sources which can produce significant thermal levels in order to define necessary controls.

Research at power density levels above 10 mW/cm^2 would be applied only to frequencies greater than 10 MHz and would be needed primarily as it relates to man for levels below 10 mW/cm^2.

The problems related to lower levels of nonionizing radiation (1 mW/cm^2 and less) are more complex and subtle than those at higher power density levels, and the complexity increases as the level decreases. At a level of 1 mW/cm^2, environmental measurements are directed toward specific areas of very high source density, while at 0.01 mW/cm^2 the emphasis shifts to the development and verification of predictive models. Most of the current research is directed toward direct health effects in the 1 to 10 mW/cm^2 range. Research requirements pertinent to a 1 mW/cm^2 guideline might be met by extensions of some on-going research programs. Levels of 0.1 through 0.01 mW/cm^2 require extensive new efforts with emphasis on determining basic mechanisms of interaction, behavioral and neurophysical effects, and on epidemiological studies. With a decrease in the radiation density level of interest, the length of time necessary to determine the effects increases, even to the extent of a generation or more.

Interference effects are of concern especially in the low level radiation density category and need further investigation because of the broad range of devices affected. Interference affects the reliability and usefullness of life support equipment such as cardiac pacemakers, hospital telemetering equipment, hospital-used electronic thermometers, critical communications such as aircraft guidance and communications, and other devices ranging from electrocardiographs to home televisions receivers.

The effects from extremely high voltage electrical power (greater than 700 kV) transmission lines include electrical shock, ozone production, electrical discharge, and induction effects into nearby objects like metal fences paralleling the power lines (11). The biological effects from the electric fields of high voltage transmission lines would be comparable to any associated with the Navy's controversial project Sanguine (16, 17, 24).

MAJOR ENVIRONMENTAL RADIATION PROTECTION ACTIVITIES

FEDERAL AGENCIES

The problems associated with nonionizing radiation are of interest to a number of governmental agencies, each having its own scope and level of effort. Figure 5-4 presents the governmental groups interested in some aspect of the problem, whether in the coordinating of programs, monitoring of sources, measuring of radiation levels, researching the effects on the environment, maintaining the safety and health of man, or developing standards. About 90 percent of the research in nonionizing radiation environmental health effects is conducted by the Department of Defense (DOD), the Environmental Protection Agency (EPA), and the Department of Health, Education and Welfare (DHEW).

At the beginning of calendar year 1974, there were 114 projects concerned with electromagnetic biological effects. These are listed by agency in Table 5-2 (30). Figure 5-5 gives a summary of the frequency distribution of electromagnetic biological effects programs for fiscal year (FY) 1974 (30). Laser and other light radiation have not been included in the summaries. During the calendar year 1974, several projects were modified, consolidated, or dropped and approximately 21 new projects were initiated. The result was that for the beginning of FY 75 there were 106 projects planned with a funding of about $7.5 million (FY 74 funding $7 million, FY 73 funding $6 million). (31)

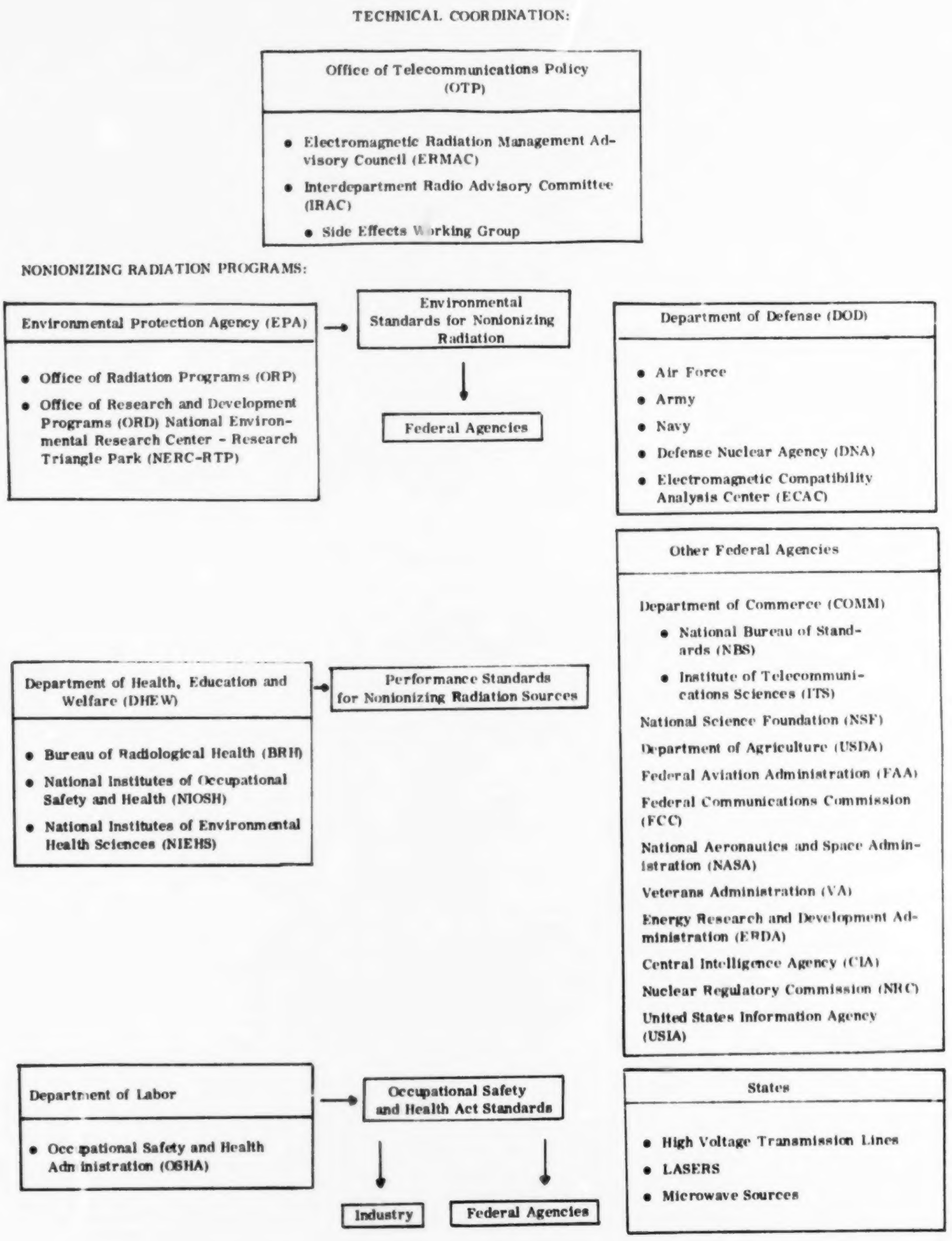

TECHNICAL COORDINATION:
Office of Telecommunications Policy (OTP)
• Electromagnetic Radiation Management Advisory Council (ERMAC)
• Interdepartment Radio Advisory Committee (IRAC)
• Side Effects Working Group
NONIONIZING RADIATION PROGRAMS:
Environmental Protection Agency (EPA)
• Office of Radiation Programs (ORP)
• Office of Research and Development Programs (ORD) National Environmental Research Center - Research Triangle Park (NERC-RTP)
Environmental Standards for Nonionizing Radiation
Federal Agencies
Department of Defense (DOD)
• Air Force
• Army
• Navy
• Defense Nuclear Agency (DNA)
• Electromagnetic Compatibility Analysis Center (ECAC)
Other Federal Agencies
Department of Commerce (COMM)
• National Bureau of Standards (NBS)
• Institute of Telecommunications Sciences (ITS)
National Science Foundation (NSF)
Department of Agriculture (USDA)
Federal Aviation Administration (FAA)
Federal Communications Commission (FCC)
National Aeronautics and Space Administration (NASA)
Veterans Administration (VA)
Energy Research and Development Administration (ERDA)
Central Intelligence Agency (CIA)
Nuclear Regulatory Commission (NRC)
United States Information Agency (USIA)
Department of Health, Education and Welfare (DHEW)
• Bureau of Radiological Health (BRH)
• National Institutes of Occupational Safety and Health (NIOSH)
• National Institutes of Environmental Health Sciences (NIEHS)
Performance Standards for Nonionizing Radiation Sources
Department of Labor
• Occupational Safety and Health Administration (OSHA)
Occupational Safety and Health Act Standards
Industry
Federal Agencies
States
• High Voltage Transmission Lines
• LASERS
• Microwave Sources

Figure 5-4
Governmental Parties Interested in Nonionizing Radiation

Agency	Projects	1 G/H/D	2 NS	3 Behav/ Psych	4 Gross Cond	5 Epidem	6 Clin Exam	7 Mech	8A Eye	8B C-V	8C Met/End Biochem	8D T/T Reg.	8E Cyt/Hist Morph	8F Other	9 Inst	10 Absorp	11 Envir/ Safety	12 Special Feature
DOD																		
Army	I 7 0 8	3,3 (1J)	2,2	1,1	---	1,1 (1J)	1,1	3,3	2,1	---	3,3	3,3	2,2	2,2	1,0	2,0	---	4,2
Navy	I=13 0 26	5,2	10,8 (1J)	12,8	5,5	---	3,3	5,5 (1J)	4,2 (2J)	1,1	12,11 (2J)	1,1	1,0 (1J)	7,7	3,3	3,2	1,1	4,4
Air Force	I=3 0 7	3,3	1,1	---	---	---	---	1,1	---	---	3,3	2,2	2,2	1,1	5,3	4,2	3,3	1,1
DNA	I 1 0-1	1,1	---	---	2,2	1,1	---	---	---	---	---	---	---	1,1	---	---	1,1	---
HEW																		
BRH	I 15 0 8	8,4 (1J)	3,3 (1J)	2,1	---	1,1 (1J)	---	3,3 (1J)	3,2 (2J)	---	4,3 (2J)	1,1	3,2 (1J)	---	3,2	3,2	2,2	3,2
NIEHS	I 4 0 1	2,0	2,2	---	---	---	---	2,2	---	---	---	---	---	---	1,1	1,1	---	---
NIOSH	I 1 0 2	---	---	---	---	---	---	---	---	---	---	---	---	---	2,0	---	1,0	---
EPA	I 11 0 1	3,2	2,2	1,1	---	1,0	---	4,4	---	---	4,4	---	1,1	2,2	3,3	---	3,3	1,1
DOC-NBS	I 8	---	---	---	---	---	---	---	---	---	---	---	---	---	6,0 (5T)	1,0 (1T)	1,0 (1T)	---
NSF	0 3	---	2,1	---	---	---	---	1,1	---	1,1	---	---	1,1	---	---	1,1	---	---
FCC	I-1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1,0	---
FAA	0-1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1,0	---
CIA	0-1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1,0
VA	I-2	---	---	1,1	---	---	---	---	1,1	---	---	---	---	---	1,1	1,1	---	---
TOTALS	114 ** I 59 0 55	24	21	17	7	3	4	18	8	2	24	7	9	13	20	15	13	14

I = number of projects conducted within the agency

0 = number of projects conducted by outside contracts, grants, or another agency

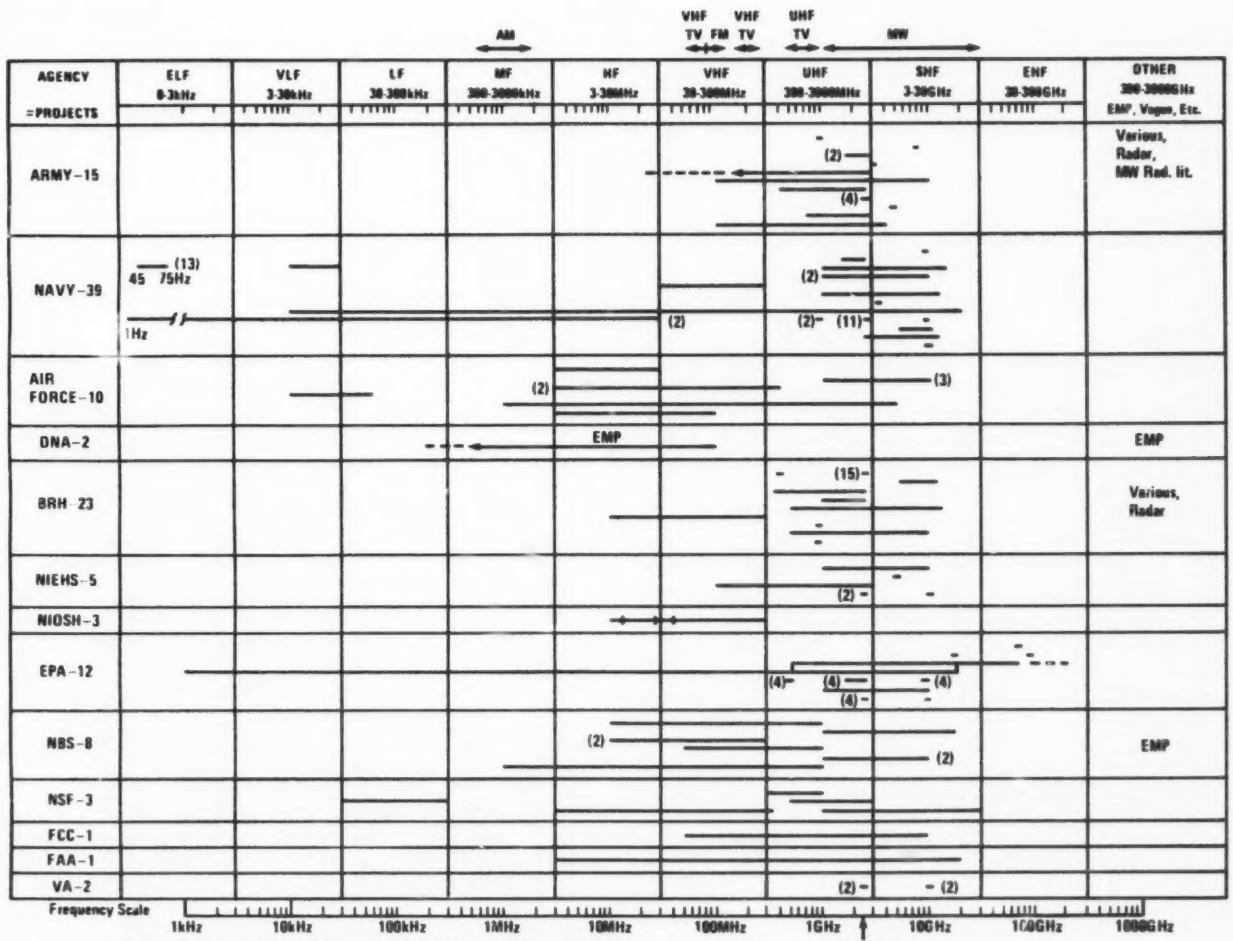
T = indicates a project funded by transfer dollars from another agency (5T) indicates 5 transfer fund projects

J = indicates a project jointly funded with another agency

* abbreviations are defined in Table 5-1

** totals are adjusted to account for joint and transfer funding In-Government = 67 non-Government = 47

Table 5-2 Electromagnetic Bioeffects Programs - FY 1974
(From Figure 4, Ref. 30)



Notes: Number in bracket indicates the number of projects in a frequency range.
A single project may deal with more than one frequency (or range).

Figure 5-5 Frequency Distribution of Electromagnetic Bioeffects Research Programs By Agency - FY 74 (From Figure 5, Ref. 30)

A majority of the projects for both FY 74 and FY 75 dealt with microwave radiation, although a cluster of research projects dealt with the effects of the frequency range 45 to 75 Hz. Even though this latter work is directed primarily toward the Navy's Project Sanguine, it is expected to provide important information relating to extremely high voltage power transmission.

Because of the diversity of works among agencies, a summary of efforts is presented for the calendar year 1974 by agency. *

OFFICE OF TELECOMMUNICATIONS POLICY

The Office of Telecommunications Policy (OTP) continued to emphasize the study of radiation exposures at relatively low power density levels over extended periods of time, as well as the study of the effects of different electromagnetic conditions. OTP also emphasizes the need to determine the clinical significance associated with any observed effects and the need to develop a sound scientific basis for remedial and/or control measures as warranted. Annually OTP publishes a report on programs for control of electromagnetic pollution of the environment, with emphasis on the biological hazards (29, 30, 31).

ELECTROMAGNETIC RADIATION MANAGEMENT ADVISORY COUNCIL

The Electromagnetic Radiation Management Advisory Council (ERMAC) is an advisory group for OTP. The Council is composed of multidisciplinary scientists, with interested Federal agencies also providing designated observers. Some liaison and coordination is made possible among Federal agencies through ERMAC activities.

In an effort to bring forth available information on nonionizing radiation, the Office of Telecommunications Policy (OTP) held a workshop/seminar (10) with the Electromagnetic Radiation Management Advisory Council on October 31, and November 1, 1974. They invited specialists and investigators to review the present state of knowledge, progress, and research pertaining to possible nervous system and behavioral effects of nonionizing radiation (a principal area of investigation in the overall multiagency program to assess biological effects of these radiations). A second session (9) on measurement of environmental levels of nonionizing electromagnetic radiation was held in February 1975. Because of the relevance of radiation from lasers, ERMAC intends to include this area of nonionizing radiation in future considerations.

*Information on several of the agencies was provided by the Office of Tele-Communications Policy from reports submitted to OTP from these agencies (31).

ENVIRONMENTAL PROTECTION AGENCY

The Environmental Protection Agency nonionizing radiation program (12) is divided between two offices. Regulatory actions and environmental measurements and evaluation are conducted by the Office of Radiation Programs in the Office of Air and Waste Management. Biological effects research is conducted by the Experimental Biology Laboratory Division in the Office of Research and Development.

During calendar year 1974 activities in the environmental measurements and evaluation area included the development of a mobile capability to measure general ambient environmental levels and to measure and analyze several specific types of sources. A semiautomated system (37) for measuring environmental levels is now scheduled to be operational early in 1975. The principal components of the system are a spectrum analyzer (20 Hz - 18 GHz), a minicomputer system to control the spectrum analyzer and to acquire and reduce data, and several antenna systems that are sensitive to the principal polarizations of signals in their respective frequency bands. The entire system is housed in a mobile van.

Land space for a facility to support the mobile monitoring capability and other program related activities is provided by the Army at the Forest Glen Annex of the Walter Reed Army Institute of Research through an Interagency Agreement. Interagency Agreements have also been established with the Electromagnetic Compatibility Analysis Center for source distribution data and with the Institute for Telecommunications Science (ITS) for antenna calibration.

A limited number of field or analytical studies have been completed on such specific sources as radar, satellite communication systems, and UHF broadcast stations. A computer program has been adapted from ITS to calculate the population in the U.S. about any point defined by its latitude and longitude. The program has been used to calculate population exposure from AM radio stations. A capability to calculate and measure electric field profiles in the vicinity of high voltage transmission lines has been established. The computer program for calculating electric field strength, adapted from one provided by the Bonneville Power Administration, has been verified against field measurements on a single 500 kV transmission line.

Biological effects research progressed during 1974 on a number of fronts. A crossed-beam apparatus for simultaneous microwave irradiation and spectrophotometric analysis was significantly improved to allow continuous monitoring of reflected power. In this system, exposure of a model protein to 1.7 and 2.45 GHz radiation had no detectable effects on the structural integrity of the molecule. Similar experiments on the binding constants of ribonuclease were nearing completion. The activities of mitochondrial and microsomal preparations exposed to 2.45 GHz radiation in this apparatus showed no differences from control levels. A flow-through system was also developed which permits the rapid measurement of mitochondrial respiratory activity immediately following exposure over a frequency of 1.7-3.0 GHz. Research capabilities have also been extended by the completion of an X-band (8.5 to 9.6 GHz) microwave exposure facility which operates under controlled environmental conditions.

Development of methodology to determine the complex dielectric constant for biological materials over a frequency range up to 9 GHz using Time-Domain-Reflectometer exposure techniques and Fast Fourier Transform Analysis was in progress. The interaction between multilayered spherical models and UHF/Microwave plane waves was used to examine the energy deposition in spheres with radii of 3.3, 6, and 10 cm over the frequency spectrum 400-4000 MHz. Work was initiated on the whole body absorption properties of animals using swept frequencies over a range of 200-525 MHz. The methods and measurements needed for determining absorbed dose rates for _in vitro_ samples under a variety of conditions, including far field exposures, were under development.

U.S. AIR FORCE

The Air Force has several program study areas. One studied internal fields in man and experimental animals in order to estimate the effects of electromagnetic radiation in man. Assymetrical power distributions, even at wavelengths much longer than the axis of man, were found to exist.

In studies of the brain areas of rats exposed to high and low impedence high frequency (HF) band fields, a strong thermal response and decreased concentrations of ATP and acetylcholine were detected. Analysis showed an uptake of zinc and alterations of magnesium content of the midbrain.

A study on zebra fish subjected to short pulse (one microsecond) and field strengths up to 7.5 kV/cm showed little effect on developing systems, other than those that can be explained by thermal effects.

The usual indicators of pathology were negative when mice were exposed for 240 days at two field levels to very low frequency (VLF) radiation. Efforts are directed toward determining if there are effects from high VLF field strengths on humans.

U.S. ARMY

During 1974, a major effort to determine microwave effects on behavior and lethality was continued and extended. Emphasis was placed on the orientation of the body relative to the electric (E) and magnetic (H) fields. In the lethality studies on rats and mice it was found that when the long axis of the rodent was oriented parallel to the E vector, increased lethality resulted.

Development efforts produced new microwave transparent probes which are superior to previous probes for use in experimental animals.

Ocular effects studies on rabbits have been completed at microwave frequencies for exposure levels of 50 to 300 mW/cm^2. The finding was that cataracts develop only at high exposure levels. Meanwhile, in another effort, data are being analyzed for 5, 10, and 25 mW/cm^2 power densities of microwave radiation on mammalian serum protein to determine the effects.

U.S. NAVY

The U.S. Navy has many projects to study nonionizing radiation. The efforts in this program are to determine safe exposure power levels and tolerance times for personnel, as well as to define the nature of possible biological effects of such exposure from communications transmitters, radars, and other military electronic equipment.

In one study, the extremely low frequency (ELF) electric and magnetic field exposures over several weeks duration on man and other representative organisms are being investigated in support of Project Sanguine. A related but separate effort shows no significant changes in temperature rhythms despite thorough studies with animals exposed for as long as three months to 45 to 75 Hz fields. However, another study indicates behavior may be affected within the EEG range (1-32 Hz) if the fields are in resonance with the dominant EEG frequency that accompanies the behavior. This relationship is seen to a slight degree through the behavioral response of monkeys in low frequency, low voltage, unmodulated electric fields within broad frequency-voltage thresholds.

The Navy has substantially changed the original design of the submarine under water communications system, Project Sanguine (17, 24), and announced in early 1975 that the project is now named "Seafarer" (16).

Electromagnetic pulse (EMP) effects are being evaluated. These are the very short duration, high peak power voltage pulses experienced as a result of a nuclear detonation. In another area neuroendocrine studies are being conducted on rats and dogs at RF and MW frequencies. In another study behavioral dysfunctions in adult male rats were associated with mild to severe body heating as a result of behavioral tests of general activity at 2.450 GHz.

BUREAU OF RADIOLOGICAL HEALTH

The Bureau of Radiological Health (BRH) of DHEW conducted several programs to help determine future performance criteria. The effort dealt with the calibration at 2450 MHz of microwave radiation measurement instruments and the completion and operation of a new high performance microwave power density calibration facility in the Division of Electronic Products. The facility has the capability to make accurate microwave measurements at many frequencies (43). In addition to calibration improvements, the development of more precise techniques for microwave measurement moved forward. In the biological area the concepts of critical tissue, delayed effects, cumulative damage, and embryonic and fetal sensitivity formed the basis for experimental design and for selection of biological end points.

NATIONAL INSTITUTE OF ENVIRONMENTAL HEALTH SCIENCE

The National Institute of Environmental Health Science (NIEHS) of DHEW concentrated on studies of effects on cell systems, embryo development, and neural response to microwave radiation at 2450 MHz. In another program, 2450 MHz radiation at 10 mW/cm^2 was studied to determine neural function effects.

NATIONAL INSTITUTE OF OCCUPATIONAL SAFETY AND HEALTH

The National Institute of Occupational Safety and Health (NIOSH) of DHEW shares responsibility for developing the scientific data, research information, and recommendations for the Nonionizing Radiation Exposure Standard (29 CFR 1910.97). This standard was updated July 1, 1974, by the Department of Labor, Occupational Safety and Health Administration. This standard covers occupational electromagnetic radiation in the frequency range 10 MHz to 100 GHz.

A radiofrequency (RF) program was set up to determine potential biological effects from RF radiation on industrial workers at the Industrial-Scientific-Medical (ISM) band frequencies of 13.56, 27.12, and 40.48 MHz. The program will identify health and safety problems experienced as a result of this RF radiation exposure. Another study was initiated as a joint Air Force - NIOSH project: research to determine the effects of RF radiation on lymphocyte division response in primates and in cell cultures over a range of 10 to 100 MHz at selected locations in man.

NATIONAL BUREAU OF STANDARDS

The National Bureau of Standards (NBS) of the Department of Commerce was called upon by other agencies to develop instrumentation. This included development of energy density meters with isotropic probes with a broad frequency response for the Navy, Air Force, and NIOSH, special electric field measurement and magnetic field measurement instruments for NIOSH, exposure chambers for biological studies, and the equipment and theory to measure and calculate antenna patterns. Another project required improvement to existing energy density meters for use around airports and aircraft for the FAA. A near field synthesizer was developed for the Air Force.

NATIONAL SCIENCE FOUNDATION

The National Science Foundation (NSF) awarded a number of grants for studies of the interaction of electromagnetic energy and biological materials through its Control and Automation Protram.

CENTRAL INTELLIGENCE AGENCY

The Central Intelligence Agency (CIA) identifies, reviews, and translates current foreign literature, making this literature available to agencies working on the biological effects from nonionizing radiation.

VETERANS ADMINISTRATION

The Veterans Administration (VA) has investigated chronic microwave exposure and its ocular and behavioral effects. The VA has also measured relatively large perturbations in field strengths due to the presence of objects in an electromagnetic field during data acquisition on absorption and field distribution. The VA is concerned with dosimetry and instrumentation to permit more accurate measurements.

FEDERAL COMMUNICATIONS COMMISSION

The Federal Communications Commission controls civilian and amateur broadcast sources, but the health effects of high powered sources are not directly considered in frequency allocation or in the siting of transmitters.

STANDARDS

The Department of Health, Education and Welfare (DHEW) is obligated by PL 90-602--known as the "Radiation Control for Health and Safety Act of 1968"--to develop and promulgate performance standards for consumer products as was done for microwave ovens. Others are presently being prepared for lasers, laser systems, and laser-containing products. The purpose of DHEW standards is to ensure that products will be manufactured to meet the appropriate performance requirements and minimize the possibility of radiation injury.

On September 4, 1974, the Food and Drug Administration of DHEW issued proposed laser performance standards (39FR32094) (44) for a second time, after receiving and reviewing numerous comments on the proposed standard issued December 10, 1973 (38FR34084). The aim of this standard is to control the electromagnetic radiation emission intensity in the wavelength range 250 through 13000 manometers (infrared, visible, and ultraviolet light ranges). Four classes of emission power are defined.

As of August 6, 1974, all microwave ovens must become inoperable if one or both of the independently operating safety interlocks fail to function (43). This is an improvement of the FDA requirement that microwave ovens manufactured after October 6, 1971, be equipped with at least two safety interlocks. The Bureau of Radiological Health of FDA is still investigating methods of defeating the interlock devices by use of common household items in order to specify further interlock design standards or guidelines.

The Department of Labor, through PL 91-596--the "Occupational Health and Safety Act of 1968"--may adopt any national consensus standard for occupational exposures, such as a standard adopted and promulgated by the

American National Standards Institute (ANSI). For example, any laser standard adopted by the Department of Labor for PL 91-596 would apply to all lasers used by workers in industry. The military services use similar guidelines to control occupational exposure.

On December 2, 1974, the American National Standards Institute (ANSI) reissued its standards (2), "Safety Level of Electromagnetic Radiation with Respect to Personnel" (ANSI C95.1-1974).

FEDERAL/STATE LEGISLATION

At the present time, there is no legislative authority for the specific control of nonionizing electromagnetic radiation pollution of the environment. However, as a pollutant, nonionizing radiation comes under the broad authority of EPA to protect the environment. In Reorganization Plan Number 3 of 1970, EPA is directed to "...by itself and together with other agencies, monitor the condition of the environment--biological as well as physical" and "...in concert with the States--to set and enforce standards for air and water quality and for individual pollutants." (27)

The Energy Reorganization Act of 1974, PL 93-438 of October 11, 1974 created the Energy Research and Development Administration (ERDA). One of its missions will be to carry on research with regards to environmental and biological impacts and to study effects of various electric transmission and generation systems.

Executive Order 11807 (September 28, 1974) made the Occupational Safety Standards applicable to federal employees, requiring protection to be "at least as effective" as OSHA standards. The new regulations became effective November 1, 1974.

A recent agreement (43) between the Food and Drug Administration and the U.S. Customs Service outlines an interagency program on electronic import control to assure that all imported electronic products comply with applicable performance standards issued under the Radiation Control for Health and Safety Act (PL 90-602).

During 1974 no new legislation was passed by the 50 states with regards to nonionizing radiation. New Jersey has a microwave oven bill (A.833) which will be carried over to the 1975 session. Three other bills, all associated with microwave ovens, failed to pass (Wisconsin S.490, New York S.9313, and Pennsylvania S.1902) (25).

COURT ACTION

Two court cases, one in Michigan involving Detroit Edison Company (Case Number 18146) and another in New York State involving Niagara-Mohawk Power Corporation, took place during 1974 in an effort to stop construction of 765 kV electrical power transmission lines. Some issues involved were shock hazard, ozone production and field effects.

FIELD STUDY

A Calverton, New York, potato farmer has charged Grumman Aerospace Corporation's Calverton facility with producing cataracts in his eyes. while he worked in his fields, via microwave radiation from the radar at the adjacent Grumman airfield. During the week of August 25, 1974, an EPA team from ORP monitored the radiation and found it to be well within the OSHA standard (29 CFR 1910.97-1974). (6, 13, 34)

HIGH VOLTAGE TRANSMISSION LINES DATA REQUEST

A high voltage electrical power transmission line radiation program commenced in ORP during 1974. Initial investigation led to the recognition of a need for data and information on the health and environmental effects associated with the operation of extremely high voltage (EHV) lines (700 kV or greater). Of particular interest are the magnitudes of the electric and magnetic fields and their impact on health and the environment. Data are also desired on phenomena which accompany electric discharge such as oxidant production, audible noise, and interference with electronic devices.

INTERNATIONAL

US/USSR EXCHANGE (43)

During May, 1974, a group of five U.S. representatives made a technical exchange visit to Soviet laboratories. The information exchange was a step towards implementation of an agreement between the two countries for scientific collaboration in the area of microwave biological effects. The collaborative work would be part of a larger program to study physical factors in the environment that affect human health.

During a December visit to the USSR, Dr. Rall, Director of the National Institute of Environmental Health Science, presented a proposed U.S. work plan and course of action for developing a cooperative microwave program in anticipation that a formal plan can be adopted during a return visit by Soviet scientists in early 1975.

BRH/WHO

The Bureau of Radiological Health (BRH) has been designated as the World Health Organization (WHO) Collaborating Centre for Standardization of Protection Against Nonionizing Radiation. The designation is for a three-year period (43).

OUTLOOK FOR THE FUTURE

Nonionizing radiation sources have substantially increased over the last several years, including sources such as microwave ovens, formerly not commercially available in significant numbers. By the end of 1974, however, it was estimated that the annual sales of microwave ovens for the home reached 600,000. The proliferation of broadcast radio and TV stations, microwave transmitters, radars, lasers, microwave ovens, high voltage electric power transmission lines, two-way remote communications, and other nonionizing radiation sources has produced the highest sustained level of nonionizing radiation exposure to the general population in history. Cheaper microwave sources are becoming available which will increase the use of frequencies above 10 GHz for communications. High power microwave systems have been proposed for use in agriculture as a substitute for herbicides and for pesticides. Industrial and medical applications of heat treatment processes also increased. Radars are being installed on some small boats used for recreation and the number continues to increase as prices are reduced. Solar energy converted to microwave frequencies for transmission from satellites to large antennas on the earth's surface has been proposed as a significant electrical energy source for the year 2000. Control in the rate of growth of radio or TV stations during the past year has been due to the limitation of frequency spectrum availability; many areas of our nation cannot accomodate more stations.

During the past decade, nonionizing radiation standards have been introduced which protect persons from microwave sources on the occupational level (7, 8) and which specify performance standards for microwave ovens (43) and lasers (44). This appears to be just the beginning. There are numerous areas for which research is not sufficiently advanced to justify-specifying power density levels. As we learn in which frequency ranges and at which power density levels biological interference effects become significant, we can expect investigations and research to produce a justification for the promulgation of standards which regulate nonionizing radiation and exposure on the environmental, occupational, and health and safety levels.

Publicity regarding the effects of nonionizing radiation has been increasing. In spite of the fact that some of the publicity has come from misinformed sources, there has been enough accurate information to make people generally aware that there is a potential problem of some magnitude. The increase in public awareness is borne out by the increased number of inquiries about nonionizing radiation made to agencies such as the EPA and DHEW. Agency public information offices have been created or expanded due to the demands of the public for more available information. Also, environmentally concerned groups have proliferated in recent years.

During recent years court actions have increased with regards to nonionizing radiation concerning alleged microwave oven and radar injuries and by citizens opposed to high voltage transmission lines construction.

Because the present ambient environmental levels of nonionizing radiation and its rate and pattern of growth are uncertain, a complete mapping of the nonionizing radiation levels in the United States needs to be carried out, at least in regions with probable high density. This effort has been established through the efforts of the Electromagnetic Radiation Analysis Branch within EPA's Office of Radiation Programs, using a mobile and automated measurement system for determining environmental radiofrequency field intensities on an absolute scale.

A determination is required as to whether there are low level effects. The answer to this question should become evident during the subsequent stages of investigation and should help in structuring a more complete research program.

Another need is the determination of criteria which can be used to specify acceptable nonionizing radiation environmental levels. Efforts have been underway to gain insight into the thermal stresses created by high levels of radiation power densities, and some low power density levels studies are underway. The effects of interference on life support systems have been investigated, especially with regards to cardiac pacemakers. In order to make a determination of the criteria for acceptable environmental levels, further research must be completed, probably over a long term, in order to provide a proper determination of effects from low power density levels.

Most nonionizing radiation experiments will undoubtedly be conducted at the frequencies associated with radio broadcast bands and higher frequencies, but it has been seen that information is also needed on the health and environmental effects from extremely high voltage (EHV) transmission lines, i.e., those operating at voltages above 700 kilovolts at 60 Hz.

At an ERMAC Seminar (10) some specific areas were identified where research emphasis should be placed: separation of electric (E) and magnetic (H) fields; comparative studies of effects of different modulations and waveforms, e.g., continuous wave (CW) radiation vs. pulses, and effects from multiple frequency exposures; parallel efforts to investigate mechanisms involved in any effects observed; more work at the biophysical, membrane, and neurochemical levels; and dosimetry, field measurements, and energy distributions to permit determination of fields, scattering within subjects, and extrapolation from one animal to another and to man. Studies of chronic exposures with durations of several months to a year also require more attention.

International cooperation will be beneficial in bringing forth, at an early date, reasonable nonionizing radiation standards that can be enforced by the respective nations. Efforts in this realm began during 1974 with U.S. scientists visiting the USSR, and a reciprocal visit early in 1975 by Soviet scientists to the U.S.

REFERENCES

1. Academy of Medical Science. Safety Standards and Regulations for Handling Sources of High, Ultrahigh and Superhigh Frequency Electromagnetic Fields, AMN (Academy of Medical Sciences), USSR, Russian, No. 848-70, March 30, 1970, 3-34.

2. American National Standards Institute. Safety Level of Electromagnetic Radiation with Respect to Personnel. Rep. ANSI-C 95.1, 1974.

3. Anderson, F.A., Ph.D. Biological Bases for and Other Aspects of a Performance Standard for Laser Products, U.S. Department of Health, Education and Welfare, DHEW Publication No. (FDA) 75-8004, July, 1974.

4. Athey, T.W., Tell, R.A., and Janes, D.E. The Use of an Automated Population Data Base in Population Exposure Calculations. Reprinted by: U.S. EPA, Office of Radiation Programs, from Population Exposures, Proceedings of the Eighth Midyear Topical Symposium of the Health Physics Society, October 1974, U.S. Environmental Protection Agency Office of Radiation Programs.

5. Britain, R.G., Director, Division of Compliance, Bureau of Radiological Health, letter to David E. Janes Office of Radiation Programs, Environmental Protection Agency, 24 July 1974.

6. Butler, W., "Feds Find Some Radiation But It's Within Standard." New York Daily News, August 28, 1974.

7. Department of Labor. Occupational Safety and Health Administration, Federal Register, Volume 36, Number 105, May 29, 1971, Section 1910.97 Nonionizing Radiation. Effective August 27, 1971.

8. Department of Labor. Occupational Safety and Health Administration, Code of Federal Regulations, Title 29 - Labor, Part 1910.97, Nonionizing Radiation, Revised as of July 1, 1974.

9. Electromagnetic Radiation Management Advisory Council, Summary of the ERMAC Work Session on Measurement of Environmental Levels of Nonionizing Electromagnetic Radiation, April 1975.

10. Electromagnetic Radiation Management Advisory Council, Summary of the ERMAC Work Session on Nervous System and Behavioral Effects of Nonionizing Electromagnetic Radiations of October 31 and November 1, 1974, and January 1975.

11. Environmental Protection Agency. Extremely High Voltage Transmission Lines: Request for Submission of Data. Federal Register, Volume 40, Number 53, FR12312, March 18, 1975.

12. EPA 1974 Nonionizing Radiation Program, Input to Office of Telecommunication Policy 1974 Report, EPA Office of Radiation Programs 1975.

13. Erbar, O., "Grumman Has Radiation Test," Long Island Press, August 27, 1974.

14. Foster, K.R., and Finch, E.D., "Microwave Hearing: Evidence for Thermoacoustic Auditory Stimulation by Pulsed Microwaves," Science Volume 185, July 19, 1974, 256-258.

15. Frey, J., Ph.D., The Growth of Microwave Systems and Applications, In Proceedings of a Session on Environmental Exposure to Nonionizing Radiation, in Proceedings of a Session on Environmental Exposure to Nonionizing Radiation, Annual Meeting of the American Public Health Association, Atlantic City, New Jersey, November 14, 1972, U.S. Environmental Protection Agency Publication EPA/ORP 73-2.

16. Getler, M., "Sanguine' Sub Network Pending 10 Years - Huge Navy Radio Revised," The Washington Post, July 18, 1974.

17. Guidry, V.A., Jr., "Sanguine Successor Is Moving," Washington Star News, March 5, 1975.

18. Hankin, N.N., An Evaluation of Selected Satellite Communications Systems as Sources of Environmental Microwave Radiation, U.S. Environmental Protection Agency EPA 520/2-74-008, December 1974.

19. Hankin, N.N., and Janes, D.E., Nonionizing Radiation Measurement Capabilities of State and Federal Agencies, U.S. Environmental Protection Agency, EPA 520/2-73-001, August 1973.

20. Hankin, N.N., Tell, R.A., Janes, D.E., Assessing the Potential for Exposure to Hazardous Levels of Microwave Radiation from High Power Sources, Presented at the 19 Annual Meeting of the Health Physics Society, Houston, Texas, July 7-11, 1974, U.S. Environmental Protection Agency, Office of Radiation Programs.

21. Healer, H.J., Federal Program on Biological Effects of Electromagnetic Energy, in Proceedings of a Session on Environmental Exposure to Nonionizing Radiation, Annual Meeting of the American Public Health Association, Atlantic City, New Jersey, November 14, 1972, U.S. Environmental Protection Agency Publication EPA/ORP 73-2.

22. Journal of Statutes, Polish People's Republic, No. 21, 1972.

23. Marha, K., Maximum Admissible Values of HF and UHF Electromagnetic Radiation at Work Places in Czechoslovakia, Symposium Proceedings: Biological Effects and Health Implications of Microwave Radiation. DHEW Publication BRH/DBE 70-2, 1970.

24. McClintock, M. and Scott, A., "Sanguine," Environment, Volume 16, Number 6, July/August, 1974.

25. Miller, L.A., Federal/State Radiation Control Legislation 1973, U.S. Department of Health, Education and Welfare, DHEW Publication (FDA) 74-8023, March 1974.

26. Morrison, M., "Laser, The Powerful Little Light that Performs Like Magic," FDA Consumer, DHEW Publication No. (FDA) 73-8040, February 1973.

27. National Radiation Protection Program Strategy, U.S. Environmental Protection Agency, Office of Radiation Programs, Document EPA-520/7-75-007, May 1975.

28. Office of Telecommunications Policy, Report on "A Summary of the Federal Government's Use of the Radio Frequency Spectrum," July 1973.

29. Office of Telecommunications Policy, Report on "Program for Control of Electromagnetic Pollution of the Environment: The Assessment of Biological Hazards of Nonionizing Electromagnetic Radiation," March 1973.

30. Office of Telecommunications Policy, Second Report of "Program for Control of Electromagnetic Pollution of the Environment: The Assessment of Biological Hazards of Nonionizing Electromagnetic Radiation," May 1974.

31. Office of Telecommunications Policy, Third Report on "Program for Control of Electromagnetic Pollution of the Environment: Assessment of Biological Hazards of Nonionizing Electromagnetic Radiation," April 1975.

32. Rowe, W.D., Janes, D.E., and Tell, R.A., An Assessment of Adverse Health Effects of Telecommunications Technology, Telecommunications Conference, Atlanta, Georgia, November 26, 1973, U.S. Environmental Protection Agency, Office of Radiation Programs, January 1975.

33. Ruggera, R.S., and Swicord, M.L., Electromagnetic Compatibility, Electromagnetic Interference and Susceptibility as Related to Medical Devices, in Proceedings of a Session on Environmental Exposure to Nonionizing Radiation Annual Meeting of the American Public Health Association, Atlantic City, New Jersey, November 14, 1972, U.S. Environmental Protection Agency Publication EPA/ORP 73-2.

34. Snider, Jane, "Health Team OK's Radar at Grumman Unit," Long Island Newsday, August 29, 1974.

35. Tell, R.A., Environmental Nonionizing Radiation Exposure: A Preliminary Analysis of the Problem and Continuing Work Within EPA, in Proceedings of a Session on Environmental Exposure to Nonionizing Radiation, Annual Meeting of the American Public Health Association, Atlantic City, New Jersey, November 14, 1972, U.S. Environmental Protection Agency Publication EPA/ORP 73-2.

36. Tell, R.A., Reference Data for Radiofrequency Emission Hazard Analysis, U.S. Environmental Protection Agency ORP/SID 72-3, June 1972.

37. Tell, R.A., Hankin, N.N., Janes, D.E., and Nelson, J.C., An Automated Measurement System for Determining Environmental Radiofrequency Field Intensities, U.S. Environmental Protection Agency, 1974.

38. Tell, R,A,, Nelson, J.C., and Hankin, N.N., HF Spectral Activity in the Washington, D.C. Area, Reprinted by: U.S. EPA, Office of Radiation Programs, from Radiation Data and Reports, Volume 15, Number 9, September 1974.

39. Tell, R.A., and Nelson, J.C., Microwave Hazard Measurements Near Various Aircraft Radars, Reprinted by: U.S. EPA Office of Radiation Programs, from Radiation Data and Reports, Volume 15, Number 4, April 1974.

40. Tell, R.A., and Nelson, J.C., RF Pulse Spectral Measurements in the Vicinity of Several Air Traffic Control Radars, U.S. Environmental Protection Agency, EPA 520/1-74-005, May 1974.

41. Threshold Limit Values of Physical Agents with Intended Changes Adopted by ACGIH for 1971, American Conference of Governmental Industrial Hygienists Publication, Cincinnati, Ohio, 1971.

42. U.S. Departments of the Army and the Air Force. Control of Hazards to Health from Microwave Radiation, Rep. TB MED 270/AFM 161-7, December 1965.

43. U.S. Department of Health, Education and Welfare. BRH Bulletin, Volume VII, Nos. 1-24, Bureau of Radiological Health, Rockville, Maryland, 1974.

44. U.S. Department of Health, Education and Welfare. Laser Products, Proposed Performance Standard, Federal Register, Vol. 39, Number 172, Part II, FR32091, September 4, 1974.

45. U.S. Department of Health, Education and Welfare, Resources and Staffing (of the Bureau of Radiological Health,) February 15, 1975.

46. Van Pelt, W.F., Payne, W.R., and Peterson, R.W., A Review of Selected Bioeffects Thresholds for Various Spectral Ranges of Light, U.S. Department of Health, Education and Welfare, DHEW Publication No. (FDA) 74-8010, June 1973.

47. Waldeskog, B., et al, Symposium Secretariat and Editorial Board, Biological Effects and Health Hazards of Microwave Radiation: Proceedings of an International Symposium (Warsaw, Poland) 15-18 October 1973, Polish Medical Publishers, Warsaw, 1974.

LIST OF ACRONYMS

ACGIH	American Conference of Governmental Industrial Hygienists
AEC	Atomic Energy Commission
AM	Amplitude Modulation
ANSI	American National Standards Institute
ASNT	American Society for Nondestructive Testing
BEIR	Biological Effects of Ionizing Radiation
BRH	Bureau of Radiological Health, DHEW
CFR	Code of Federal Regulations
CIA	Central Intelligence Agency
COMM	Department of Commerce
CW	Continuous Wave
DAP	Diammonium Phosphate
DCPA	Defense Civil Preparedness Agency
DHEW	Department of Health, Education and Welfare
DNA	Defense Nuclear Agency, DOD
DOD	Department of Defense
DOL	Department of Labor
DOT	Department of Transportation
ECAC	Electromagnetic Compatibility Analysis Center, DOD
EHF	Extremely High Frequency, 30-300 GHz
EIS	Environmental Impact Statement

ELF	Extremely Low Frequency, 3-3000 Hz
EM	Electromagnetic
EMR	Electromagnetic Radiation
EPA	Environmental Protection Agency
ERAB	Electromagnetic Radiation Analysis Branch, ORP
ERAC	Electromagnetic Compatibility Analysis Center, DOD
ERAMS	Environmental Radiation Ambient Monitoring System
ERDA	Energy Research and Development Administration
ERMAC	Electromagnetic Radiation Management Advisory Council
FAA	Federal Aviation Agency
FCC	Federal Communications Commission
FDA	Food and Drug Administration
FDA/BRH	Food and Drug Administration/Bureau of Radiological Health
FM	Frequency Modulation
FOD	Field Operations Division, ORP
FPC	Federal Power Commission
FR	Federal Register
FWPCA	Federal Water Pollution Control Act (of 1974)
GESMO	Generic Environmental Statement on Mixed Oxide Fuels
GHz	Gigahertz, 1,000,000,000 Hz (1,000 MHz)
GSA	General Services Administration
HF	High Frequency, 3-30 MHz
Hz	Hertz
IAEA	International Atomic Energy Agency

ICRP	International Commission on Radiation Protection
IRAC	Interdepartment Radio Advisory Committee
ITS	Institute of Telecommunication Science, COMM
kV	Kilovolt (1,000 volts)
LF	Low Frequency, 30-300 kHz
LMFBR	Liquid Metal Fast Breeder Reactor
LWR	Light Water Reactor (or Light-Water-Cooled Reactor)
MAP	Monoammonium Phosphate
MF	Medium Frequency, 300-3,000 kHz
MHz	Megahertz, 1,000,000 Hz (1,000 kHz)
mrem	Millirems
mW	Milliwatt, 1/1,000 watt
MW	Microwave
NASA	National Aeronautics and Space Administration
NBS	National Bureau of Standards, COMM
NDT	Nondestructive Testing
NEPA	National Environmental Protection Act
NERC	National Environmental Research Center, EPA
NEXT	Nationwide Evaluation of X-Ray Trends
NIEHS	National Institute of Environmental Health Sciences, DHEW
NIOSH	National Institute of Occupational Safety and Health
NRC	Nuclear Regulatory Commission
NRDC	National Resource Defense Council
NSF	National Science Foundation

OP	Office of Preparedness, GSA
ORD	Office of Research and Development, EPA
ORP	Office of Radiation Programs, EPA
ORP-LVF	Office of Radiation Programs-Las Vegas Facility
OSHA	Occupation Safety and Health Administration, DOL
OTP	Office of Telecommunications Policy,
pCi	Pico Curies
PAG	Protective Action Guides
RF	Radio Frequency
RSSF	Retrievable Surface Storage Facility
SHF	Super High Frequency, 3-30 GHz (3,000-30,000 MHz)
TLD	Thermoluminescent Dosimeter
TSP	Triple Superphosphate
UHF	Ultra High Frequency, 300-3,000 MHz
USDA	U.S. Department of Agriculture
USEPA	U.S. Environmental Protection Agency
USIA	U.S. Information Agency
VA	Veterans Administration
VHF	Very High Frequency, 30-300 MHz
VLF	Very Low Frequency, 3-30 kHz
WHO	World Health Organization, United Nations

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